United States Government Accountability Office

Report to Congressional Committees

March 2016

DEFENSE ACQUISITIONS

Assessments of Selected Weapon Programs

GAO-16-329SP

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GAO Highlights

Highlights of GAO-16-329SP, a report to congressional committees

Why GAO Did This Study

This is GAO's annual assessment of DOD major weapon system acquisitions, an area on GAO's high-risk list. DOD and Congress have taken meaningful steps to improve the acquisition of major weapon systems, yet programs continue to experience cost and schedule overruns. Further, GAO has emphasized the need to sustain the implementation of acquisition reforms and for programs to complete developmental testing before beginning production, thereby avoiding concurrency and its associated cost and schedule growth. With the continuing budgetary pressures, DOD cannot afford to miss opportunities to address inefficiencies in these programs to free up resources for higher priority needs.

The joint explanatory statement to the DOD Appropriations Act, 2009 includes a provision for GAO to annually review DOD's portfolio of weapon systems. This report includes observations on (1) the cost and schedule performance of DOD's 2015 portfolio of 79 major defense acquisition programs; (2) the knowledge attained at key junctures in the acquisition process for 43 programs that were in development or early production; and (3) key acquisition reform initiatives and program concurrency. To develop the observations in this report, GAO analyzed cost, schedule, and quantity data from DOD's December 2014 Selected Acquisition Reports. GAO also collected data through two questionnaires to program offices on technology, design, and manufacturing knowledge; the use of knowledge-based acquisition practices; and the implementation of acquisition reforms and initiatives.

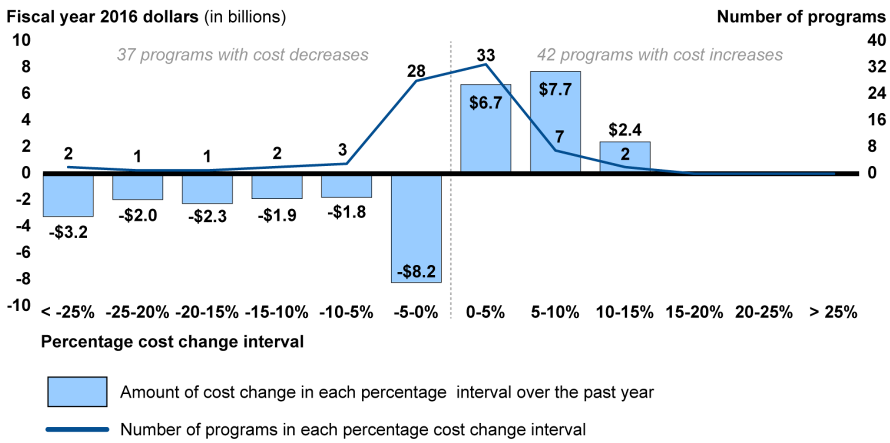
In commenting on a draft of this report DOD agreed with our findings and noted that our results appear to validate DOD's focus on continuous improvements.

View GAO-16-329SP. For more information, contact Michael J. Sullivan at (202) 512-4841 or sullivanm@gao.gov

What GAO Found

Over the past year, the number of programs in the Department of Defense's (DOD) portfolio of major defense acquisitions increased from 78 to 79, while DOD's total planned investment in these programs decreased from $1.45 trillion to $1.44 trillion. This estimate is in line with a trend seen since 2010 of decreases in the portfolio's total acquisition cost. The portfolio's cost growth since first full estimates has been substantial, but most of the cost growth occurred 5 or more years ago. The average time to deliver initial capability to the warfighter also increased by 2.4 months. This increase is due in part to the significant delays experienced by a few programs. In addition, while more programs in the 2015 portfolio reported cost increases than decreases the net change resulted in a decrease in the portfolio's total cost over the past year.

Distribution of the 1-year Change in Total Acquisition Cost within the 2015 Portfolio



Source: GAO analysis of DOD data. | GAO-16-329SP

Most of the 43 programs GAO assessed this year are not yet fully following a knowledge-based acquisition approach, as GAO recommended. This held true for the 7 programs that recently entered system development as none completed all of our criteria for a best practices approach. Each of the 7 implemented some knowledge based practices—such as constraining the period for development—but other practices—such as fully maturing technologies prior to system development start and completing systems engineering reviews—were not fully implemented. As a result, these programs will carry unwanted risk into subsequent phases of acquisition that could result in cost growth or schedule delays.

Implementation of the reform initiatives GAO analyzed varies for the 43 programs assessed above as well as the 12 assessed that will become programs in the future. Programs are implementing acquisition reform initiatives—such as the use of affordability constraints and "should cost" analysis—and have realized $21 billion in savings as a result. However, there has been a decrease in the number of programs with acquisition strategies that include competition. In addition, a number of programs are concurrently conducting both software and hardware development during production, exposing programs to undue cost and schedule risk.

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Abbreviations

ACV	Amphibious Combat Vehicle
APT	Advanced Pilot Training
AMDR	Air and Missile Defense Radar
B-2 DMS-M	B-2 Defensive Management System Modernization
BMDS	Ballistic Missile Defense System
CIRCM	Common Infrared Countermeasures
DAMIR	Defense Acquisition Management Information Retrieval
DOD	Department of Defense
eSRS	Electronic Subcontracting Reporting System
F-15 EPAWSS	F-15 Eagle Passive/Active Warning and Survivability System
F-22 Inc 3.2 B	F-22 Increment 3.2 B Modernization
FAB-T	Family of Advanced Beyond Line-of-Sight Terminals
IFPC Inc 2	Indirect Fire Protection Capability Increment 2
ITEP	Improved Turbine Engine Program
JAGM	Joint Air-to-Ground Missile
JLTV	Joint Light Tactical Vehicle
JSTARS Recap	Joint Surveillance Target Attack Radar System Recapitalization
LX(R)	Amphibious Ship Replacement
MDAP	Major Defense Acquisition Program
MGUE	Military GPS User Equipment Increment 1
MRL	manufacturing readiness level
NA	not applicable
NGJ Inc 1	Next Generation Jammer Increment 1
OASuW Inc 1	Offensive Anti-Surface Warfare Increment 1
OR	Ohio-Class Replacement
OMB	Office of Management and Budget
P-8A Inc 3	P-8A Poseidon Increment 3
PAR	Presidential Aircraft Recapitalization
SAR	Selected Acquisition Report
SDB II	Small Diameter Bomb Increment II
Space Fence Inc 1	Space Fence Ground-Based Radar System Increment I
SSC	Ship to Shore Connector Amphibious Craft
T-AO(X)	Fleet Replenishment Oiler
TBD	to be determined
TRL	technology readiness level

UCLASS	Unmanned Carrier-Launched Airborne Surveillance and Strike system
WSARA	Weapon Systems Acquisition Reform Act
WSF	Weather Satellite Follow-On

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Comptroller General
of the United States

March 31, 2016

Congressional Committees

I am pleased to present GAO's 14th annual assessment of the Department of Defense's (DOD) major defense acquisition programs. This report offers observations on the performance of DOD's current $1.4 trillion portfolio of 79 programs, the smallest portfolio in terms of total cost in a decade.[1] These 79 programs will require roughly a third of all DOD's development and procurement funding over the next 5 years. The level of investment these programs require makes it imperative that DOD continue its oversight of the implementation of key legislative and policy reforms it began in 2010 as well as the implementation of the best practices developed by GAO. In previous assessments, we reported that some of these reforms are addressing problems in DOD acquisitions. Our current assessment shows that these acquisition reforms and GAO's best practices are not uniformly implemented across the portfolio. As a result, some programs continue to realize significant cost growth and delays in delivering needed capability. Critically, new programs started each year fulfill only some of the best practices intended to achieve a level of knowledge that would demonstrate they are capable of meeting their performance requirements while meeting cost and schedule commitments. The highest point of leverage is at the start of a new program. Decision makers must ensure that new programs exhibit desirable principles before they are approved and funded.

Our current assessment shows that DOD is making progress in decreasing the amount of cost growth realized in the portfolio. When compared to the 78 major defense acquisition programs in last year's portfolio the current estimated cost of the 79 programs in the 2015 portfolio is nearly $15 billion less despite a net increase in programs. When assessing just the 79 programs in the 2015 portfolio costs have

[1]Our assessment of DOD's portfolio does not include the cost of the Ballistic Missile Defense System (BMDS), which we exclude as the program lacks an acquisition program baseline needed to support our assessment of cost and schedule change. For more information on BMDS, see GAO, *Missile Defense: Opportunities Exist to Reduce Acquisition Risk and Improve Reporting on System Capabilities,* GAO-15-345 (Washington, D.C.: May 6, 2015)

decreased by $2.5 billion over the past year, a net decrease largely attributable to quantity reductions in the Patriot Advanced Capability-3 Missile Segment Enhancement program. In particular, programs that started development after the implementation of the Weapon Systems Acquisition Reform Act of 2009 (WSARA) and DOD's "Better Buying Power" initiatives began in 2010 have achieved cost reductions or shown less cost growth than those that began development before 2010, indicating that recent reforms may be having a positive effect. This trend is continued when looking at the 2015 portfolio's $469 billion in cost growth since first full estimates as $373 billion of the growth occurred five or more years ago. Additionally, older programs in the portfolio carry a majority of this growth compared to newer programs.

However, our analysis also highlights areas that still need attention such as the use of knowledge-based best practices. For example, some programs are still carrying technology risk well into system development or are proceeding into production before manufacturing processes are under control. Not following knowledge-based best practices puts these programs at increased risk of unsatisfactory acquisition outcomes. Our assessment does show a similar number of programs are implementing initiatives focused on reducing cost through affordability constraints and efforts to find cost savings. In contrast, we also found less use of competition measures throughout the acquisition life cycle and overlap between developmental testing and production, which threaten programs' abilities to meet their cost, schedule, and performance objectives. In addition, we have a new observation on the defense industrial base showing that the companies developing and delivering the largest DOD programs are performing well in the market. We plan to have more analysis in this area in our next assessment.

Weapon system acquisitions remain an area on GAO's high-risk list.[2] Continued efforts by DOD to mitigate these risks through adherence to best practices and effective program management are essential.

Gene L. Dodaro
Comptroller General
of the United States

[2]GAO, High-Risk Series: An Update, GAO-15-290 (Washington, D.C.: February 11, 2015).

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March 31, 2016

Congressional Committees

The joint explanatory statement to the Department of Defense Appropriations Act, 2009, included a provision for GAO to annually review the department's $1.4 trillion portfolio of major weapon programs.[3] This report also includes information related to small business participation pursuant to a mandate in a report for the National Defense Authorization Act for Fiscal Year 2013.[4] Additionally, this report's assessment of the Amphibious Combat Vehicle (ACV) along with GAO's October 2015 report on the ACV program constitute GAO's response to the annual reporting requirement for 2016 required by the National Defense Authorization Act for Fiscal Year 2014.[5]

This report includes observations on (1) the cost and schedule performance of DOD's 2015 portfolio of 79 major defense acquisition programs, (2) the knowledge attained at key junctures in the acquisition process for 55 current and future weapon programs in development or

[3]See Explanatory Statement, 154 Cong. Rec. H 9427, 9526 (daily ed., Sept. 24, 2008), to the Department of Defense Appropriations Act, 2009, contained in Division C of the Consolidated Security, Disaster Assistance, and Continuing Appropriations Act, 2009, Pub. L. No. 110-329 (2008).

[4]H.R. Rep. No. 112-479, at 284 (2012). The National Defense Authorization Act for Fiscal Year 2013, Pub. L. No.112-239.

[5]GAO, *Amphibious Combat Vehicle: Some Acquisition Activities Demonstrate Best Practices; Attainment of Amphibious Capability to be Determined*, GAO-16-22 (Washington, D.C.: Oct. 28, 2015). The National Defense Authorization Act for Fiscal Year 2014, Pub. L. No.113-66, § 251 (2013).

early production, and (3) key acquisition reform initiatives and whether programs are conducting or planning concurrent testing and production.[6]

Our observations in this report are based on three sets of programs:

- We assessed 79 major defense acquisition programs in DOD's 2015 portfolio for our analysis of cost and schedule performance. We obtained cost, schedule, and quantity data from DOD's December 2014 Selected Acquisition Reports (SAR) and from the Defense Acquisition Management Information Retrieval Purview (DAMIR) system. We assessed the reliability of the data by interviewing knowledgeable agency officials on the steps they take to ensure data reliability, and determined that the data were sufficiently reliable for the purposes of this report.

- We assessed 43 major defense acquisition programs currently between the start of development and the early stages of production for knowledge attained at key junctures and their implementation of acquisition reforms. We obtained information on the extent to which the programs follow knowledge-based practices—established by the oeuvre included in the Related GAO Products section of this report—for technology maturity, design stability, and production maturity using two data-collection instruments. One was a questionnaire on issues such as systems engineering reviews, design drawings, manufacturing planning and execution, and the implementation of specific acquisition reforms. The other was a data-collection instrument used to collect schedule dates, the programs' critical technology levels, and other information. We received questionnaire responses from all 43 current programs from August through October 2015.

- We also assessed 12 future major defense acquisition programs not yet in the portfolio in order to gain additional insights into knowledge

[6]Major defense acquisition programs (MDAP) are those identified by DOD with a dollar value for all increments estimated to require eventual total expenditure for research, development, test, and evaluation of more than $480 million, or for procurement of more than $2.79 billion, in fiscal year 2014 constant dollars. DOD has a list of programs designated as future major defense acquisition programs. These programs have not formally been designated as MDAPs; however, DOD plans for these programs to enter system development, or bypass development and begin production, at which point they will likely be designated as MDAPs. We refer to these programs as future major defense acquisition programs throughout this report.

attained before the start of development and their plans for implementation of key acquisition reform initiatives. We submitted a questionnaire to program offices to collect information on issues such as program schedule events, costs, and numerous acquisition reforms, and received responses from all 12 future programs from July through August 2015.

We present individual assessments of 55 programs—43 current and 12 future weapon programs. These assessments include major defense acquisition programs currently in development or early production as well as future programs. Appendix I contains detailed information on our scope and methodology.

We conducted this performance audit from June 2015 to March 2016 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings based on our audit objectives.

Observations on the Cost and Schedule Performance of DOD's 2015 Major Defense Acquisition Program Portfolio

Since 2014, the number of programs in DOD's portfolio of major defense acquisitions increased from 78 to 79, and DOD's total planned investment in these programs decreased by nearly $15 billion from $1.45 trillion to $1.44 trillion. This estimate is in line with a trend seen since 2010 of decreases in the portfolio's total acquisition cost. The programs in the 2015 portfolio reported an increase in the average schedule delay in achieving initial capability of 2.4 months over the past year. The total amount of funding needed to complete the 2015 portfolio is estimated at $603 billion, which is a decrease from the 2014 portfolio and is the lowest amount in over a decade. Of the $603 billion, $571 billion is planned for procurement and $32 billion is planned for development. We also found that more programs reported gains in buying power when compared to programs in the previous portfolio. Despite the portfolio's overall cost decrease, 42 of 79 programs increased in cost over the past year and the entire portfolio experienced $469 billion in cost growth since programs established their first full estimates, primarily due to cost growth that occurred 5 or more years ago.

Our analysis of DOD's 2015 portfolio allows us to make the following 11 observations.

Cost and Schedule Performance Observations

Changes across portfolios

1. When compared to the 2014 portfolio, the cost of the 2015 portfolio decreased by nearly $15 billion from $1,455 to $1,440 billion and the number of programs in the portfolio increased by one to 79.[a]
2. The total amount of funding required for the portfolio has been decreasing since 2010.[b] The amount of future funding needed to complete the portfolio—$603 billion—is at its lowest point in over a decade. Of the $603 billion of future funding, $571 billion is for procurement and $32 billion is for development. The low amount of future development funding required is likely due to a number of factors, including newer programs with less risk entering system development.

Changes in the 2015 portfolio

3. The cost estimates over the past year for the 79 programs in the 2015 portfolio decreased by $2.5 billion and the average schedule delay in achieving initial capability increased by 2.4 months. When assessed against first full estimates, total costs have increased by $469 billion, over 48 percent, most of which occurred over 5 years ago. The average delay in delivering initial capabilities has increased to almost 30 months.

Factors that explain changes in the 2015 portfolio

4. Older programs in the portfolio carry a majority of the total cost and cost growth since first full estimates when compared to newer programs. Of the 79 programs in the 2015 portfolio, 40 were also in the 2005 portfolio and represent 80 percent of the portfolio's total acquisition cost—over $1.1 trillion of the $1.4 trillion total.
5. While the total cost of the 2015 portfolio decreased, 42 of the 79 programs increased in cost over the past year. Cost estimate decreases on 37 programs resulted in the overall net cost decrease.
6. Thirty-eight programs in the portfolio gained buying power during the past year resulting in a net gain of $10.7 billion. Six programs in our analysis have demonstrated buying power gains or losses on an annual basis over the past 5 years.
7. Schedule delays over the past year in 11 of the 79 programs contributed to the portfolio's overall delay of 2.4 months. The Airborne Maritime/Fixed Station radio system experienced the largest delay at more than 8 years, which disproportionately affected the portfolio.
8. Over the past year, 16 programs reported development cost growth while in production, a phase of the acquisition cycle that should have minimal development cost growth. This represents concurrency, albeit for different reasons, and is a contributor to cost growth.

Other Observations

9. As measured against the metrics discussed with the Office of Management and Budget (OMB) and DOD, more programs meet each metric for cost change than our last assessment. Most notably, 72 percent of programs meet the threshold for less than 10 percent growth over the past 5 years. Seventy-six percent meet the threshold for less than 2 percent growth in the past year. Forty-seven percent meet the threshold for less than 15 percent cost growth since first full estimates.
10. Army programs' percentage of the total cost of the portfolio is the smallest of the services and has been decreasing since 2007. The Navy and Air Force programs' percentages have been increasing since 2007 and 2012 respectively. Navy programs account for almost 55 percent of the 2015 portfolio's total estimated acquisition cost.
11. The equity prices of contractors delivering the 10 costliest programs have performed well relative to broad-based market indices, indicating that investors expect these firms to remain profitable well into the future.

[a]All dollar figures are in fiscal year 2016 constant dollars, unless otherwise noted.

[b]Details on program costs used for this analysis are provided in appendix I.

Changes across Portfolios

1. **When compared to the 2014 portfolio, the cost of the 2015 portfolio decreased by nearly $15 billion—from $1,455 to $1,440 billion—and the number of programs in the portfolio increased by one to 79.** The decrease in cost is due primarily to the five programs that exited the portfolio and accounted for $39 billion in spending. Three of these 5 programs completed their planned development and procurement—the MH-60S Fleet Combat Support Helicopter, the National Airspace System, and the Patriot Advanced Capability program—and accounted for over $24 billion in cost. The termination of the Patriot/Medium Extended Air Defense System Combined Aggregate Program and restructuring of the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System accounted for $14.5 billion of the remaining $39 billion. The 6 programs entering the portfolio have a total estimated cost of $24 billion. The changes from the 2014 portfolio to the 2015 portfolio are outlined in table 1 below.

Table 1: Cost Changes of DOD's Major Defense Acquisition Programs from 2014 to 2015

Fiscal year 2016 dollars (in billions)	
2014 portfolio (78 programs)	**$1,455**
Less estimated total cost of the 5 exiting programs	-$39
Plus estimated total cost of the 6 entering programs	+$24
Less net cost changes on the 73 remaining programs	-$1
2015 portfolio (79 programs)	**$1,440**

Source: GAO analysis of DOD data. | GAO-16-329SP

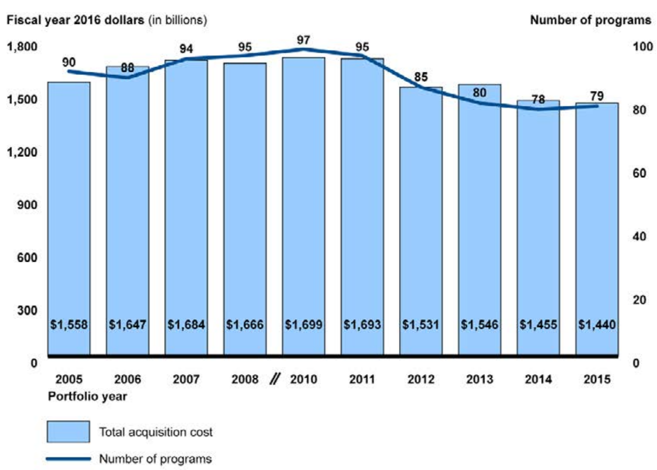
Note: Our assessment of DOD's 2014 and 2015 portfolios does not include the cost of the Ballistic Missile Defense System (BMDS), which we exclude as the program lacks an acquisition program baseline needed to support our assessment of cost and schedule change. Some numbers may not sum due to rounding.

Six programs began system development and entered the portfolio, the Combat Rescue Helicopter, Enhanced Polar System, Intercontinental Ballistic Missile Fuze Modernization, Patriot Advanced Capability-3 Missile Segment Enhancement, Space Fence Ground-Based Radar System Increment 1, and the VH-92A Presidential Helicopter. The Patriot Advanced Capability-3 Missile Segment Enhancement is leveraging the resources and development conducted by the Patriot/Medium Extended Air Defense System Combined Aggregate Program's Missile Unit sub-element. Two programs—the Combat Rescue Helicopter and the VH-92A Presidential Helicopter—come from previously canceled acquisition

programs. The remaining three programs were in technology development before their entry into the portfolio was approved.

2. **The total cost of the portfolio has been decreasing since 2010. The amount of future funding needed to complete the portfolio—$603 billion—is at its lowest point in over a decade. Of the $603 billion of future funding, $571 billion is for procurement and only $32 billion is for development. The low level of remaining development funding is likely due to many factors, including newer programs with less risk entering system development.** The cost and number of programs in the portfolio has decreased over the past 5 years as more programs have exited than entered, the programs entering are less costly, and ongoing programs are realizing cost savings. Currently, the total acquisition cost of the portfolio is estimated at $1.4 trillion, including $603 billion for future funding. Programs started in the past 5 years account for just 15 percent of that $603 billion. Figure 1 shows the changes in total cost and number of programs within DOD's portfolio of major weapon acquisitions since 2005.

Figure 1: DOD Portfolio Cost and Size, 2005-2015



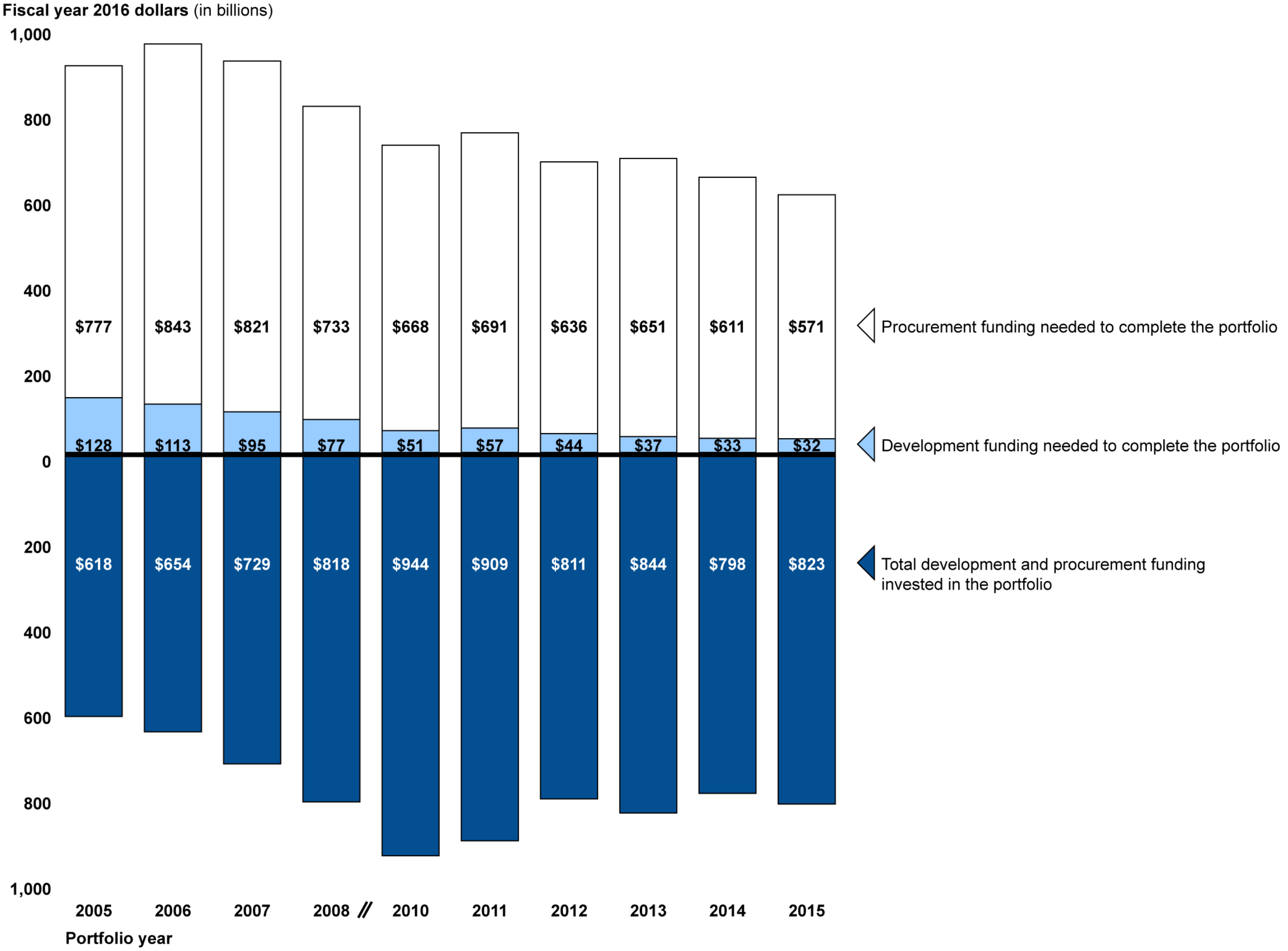
Source: GAO analysis of DOD data. | GAO-16-329SP

Note: The 2009 portfolio is excluded because there were no annual Selected Acquisition Reports (SAR) released for the December 2008 submission date.

The amount of development and procurement funding needed to complete the 2015 portfolio, $571 billion in procurement and $32 billion for development, has been generally decreasing.[7] By contrast, in 2005 future funding was over $904 billion, or 58 percent, of the portfolio's total cost. Figure 2 shows the change in the portfolio's future funding needs and funding invested as a share of the portfolio's total acquisition cost since 2005.

[7]Other costs include military construction and operations and maintenance, which account for $13.1 billion of the 2015 portfolio's total acquisition cost.

Figure 2: DOD Portfolio Future Development and Procurement Funding in Comparison to Invested Funding by Year, 2005-2015



Source: GAO analysis of DOD data. | GAO-16-329SP

Note: The 2009 portfolio is excluded because there were no annual Selected Acquisition Reports released in December 2008.

The estimated cost to complete the research and development associated with the portfolio is at the lowest point in a decade, approximately $32 billion. Several factors may have contributed to this low level of future development funds, such as

- declining budgets;

- newer programs based on more reasonable requirements that leverage mature technologies or modify existing designs;
- a majority of programs are in early or full production—a phase in the acquisition life cycle that should require less development funding; and
- several programs starting system development over the past two years have chosen potentially less-risky or less complex acquisition approaches, such as acquiring capability in increments and trading capability for affordability.

Changes in the 2015 portfolio

3. **Over the past year, the total acquisition cost for the 79 programs in the 2015 portfolio decreased by $2.5 billion and the average schedule delay in achieving initial capability increased by 2.4 months. When assessed against first full estimates, total costs have increased by $469 billion, over 48 percent, most of which occurred over 5 years ago. The average delay in delivering initial capabilities has increased to almost 30 months.** While the first observation discusses the change from the prior portfolio of 78 programs to the current portfolio of 79 programs, this observation addresses the change that occurred on the 79 programs in the current portfolio. Table 2 shows the change in cost and schedule for the 2015 portfolio in the past year.

Table 2: Changes in DOD's 2015 Portfolio of 79 Major Defense Acquisition Programs over the Past Year

Fiscal year 2016 dollars (in billions)	Estimated portfolio cost in 2014	Estimated portfolio cost in 2015	Estimated portfolio change since 2014	Percentage change since 2014
Total estimated research and development cost	**$285.9**	**$289.0**	**$3.1**	**1.1%**
Total estimated procurement cost	**1,143.5**	**1,137.6**	**-6.0**	**-0.5**
Total estimated acquisition cost[a]	**1,442.0**	**1,439.6**	**-2.5**	**-0.2**
Average delay in delivering initial capabilities from the first full estimate of cost and schedule	27 months	29.5 months	2.4 months additional delay	1.3

Source: GAO analysis of DOD data. | GAO-16-329SP

[a]In addition to research and development and procurement costs, total acquisition cost includes acquisition-related operation and maintenance and system-specific military construction costs. Some numbers may not sum due to rounding.

The current portfolio's total acquisition cost has decreased over the past year by $2.5 billion, due primarily to a $6.0 billion decrease in

procurement costs which offset a $3.1 billion increase in development costs. The Patriot Advanced Capability-3 Missile Segment Enhancement program accounts for $2 billion of the $2.5 billion decrease due to a quantity reduction of 28.5 percent.

When measuring the current portfolio's schedule performance over the past year, we found that the delay in delivery of initial operating capability grew almost two and a half months over the past year and now stands at 29.5 months from initial estimates.[8]

When assessed against first full estimates, the total cost of the 2015 portfolio increased by nearly $469 billion, or 48 percent, most of which occurred more than 5 years ago.[9] These cost estimates and percent growth are consistent with what we reported in our prior assessment.

Factors That Explain the Changes in the 2015 Portfolio

4. **Older programs in the portfolio carry a majority of the total cost and cost growth since first full estimates compared to newer programs. Of the 79 programs in the 2015 portfolio, 40 were also in the 2005 portfolio and represent 80 percent of the portfolio's total acquisition cost—over $1.1 trillion of the $1.4 trillion total.** The 40 programs common to the 2005 and 2015 portfolios range in age between 11 and 38 years. These programs account for 80 percent of the current portfolio's $1.4 trillion in total acquisition cost. Consequently, the 40 newer programs account for just 20 percent of the total portfolio acquisition cost.

   The total acquisition cost of the portfolio is also driven in large part by the 10 costliest programs, which currently account for $866 billion, or 60 percent of the portfolio's total cost. Nine of the 10 costliest programs in the 2015 portfolio were also in the 2005 portfolio. These programs are over 11 years old and account for 65 percent of the portfolio's cost growth since first full estimates as shown in table 3 below.

[8] When calculating this delay, we obtained schedule information for the cycle time from program start to initial operational capability as reported in the previous year and contrasted it with the current schedule.

[9] The first full estimate is generally the cost estimate established at the start of system development, for more information see Appendix I. For more information on the portfolio's performance since first full estimates, see Appendix III.

Table 3: Programs with the Largest Total Acquisition Cost in the 2015 Portfolio
Fiscal year 2016 dollars (in billions)

Program	Years since first full estimate	Total acquisition cost	Total acquisition cost growth since initial estimates
F-35 Joint Strike Fighter	14	$340	$111
DDG 51 Arleigh Burke Class Guided Missile Destroyer	33	115	99
SSN 774 Virginia Class Submarine	21	91	26
V-22 Osprey Joint Services Advanced Vertical Lift Aircraft	33	62	19
Evolved Expendable Launch Vehicle	19	61	42
Trident II Missile	38	58	2
KC-46 Tanker Modernization Program	4.9	44	-4
Gerald R. Ford Class Nuclear Aircraft Carrier	11.7	36	-2
P-8A Poseidon Multi-Mission Maritime Aircraft	15.8	33	.03
UH-60M Black Hawk Helicopter	14.7	26	12
Ten costliest programs		**$866**	**$306**
Remaining portfolio total		**$574**	**$163**
2015 portfolio total		**$1,440**	**$469**

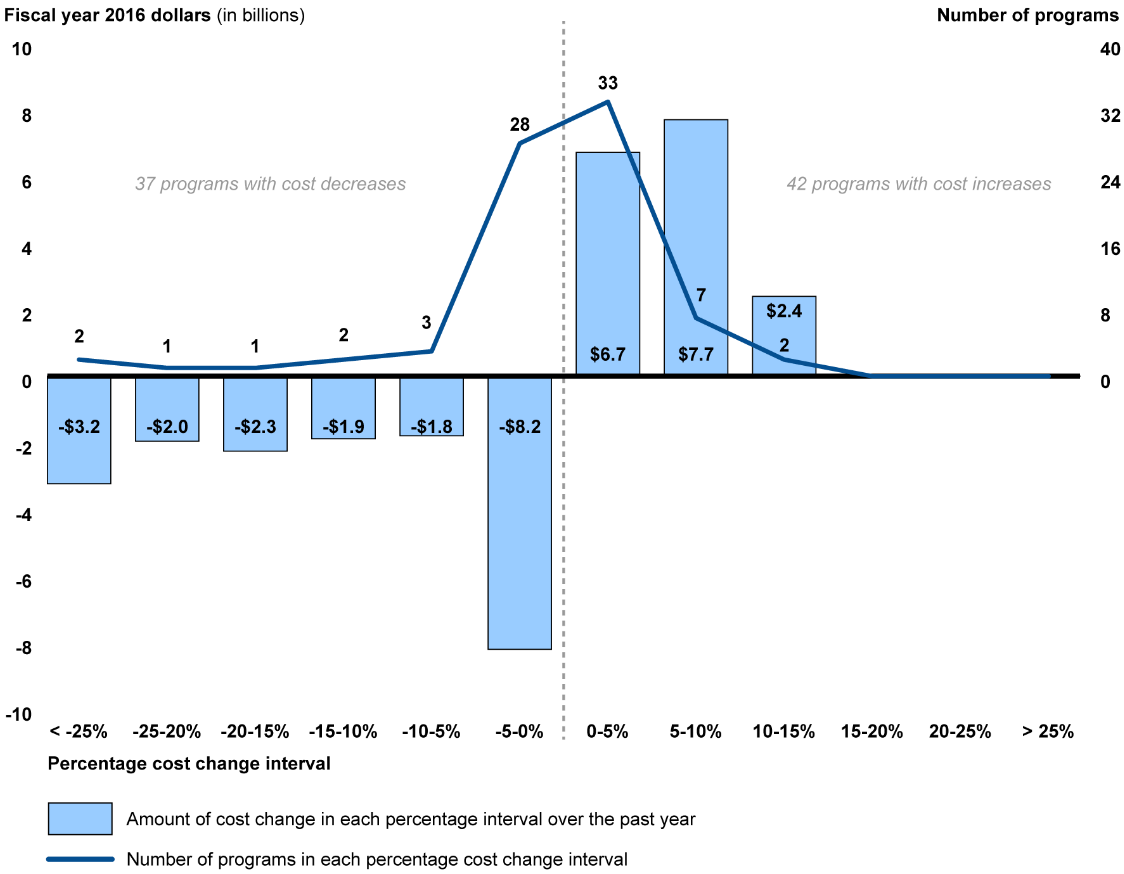
Source: GAO analysis of DOD data. | GAO-16-329SP

Eighty percent of the 2015 portfolio's cost growth since first full estimates—$373 billion—occurred five or more years ago. Since 2010, the current portfolio has accumulated $95.7 billion in cost growth, about 20 percent of the $469 billion total. That same year, DOD began implementation of WSARA and its "Better Buying Power" initiatives.[10] In addition, our analysis also shows that programs started since WSARA and the "Better Buying Power" initiatives have realized cost decreases from their first full estimates. The 14 programs that began system development since 2010 have collectively reduced their total estimated acquisition costs by over $580 million since their first full estimates. However, these programs have only recently begun development and may encounter issues in the future. DOD and Congress will need to continue oversight to ensure they do not increase in cost.

[10] Pub. L. No. 111-23.

5. **Of the 79 programs, 37 saw $19.3 billion in cost decreases while 42 programs experienced $16.8 billion in cost increases resulting in a net decrease in the total acquisition cost of nearly $2.5 billion.** The $2.5 billion decrease shown in table 2 above is the net result of cost changes on all 79 programs in the current portfolio. The distribution of those cost changes across the entire portfolio is shown below in figure 3.

Figure 3: Distribution of the 1-year Change in Total Acquisition Cost within the 2015 Portfolio



Source: GAO analysis of DOD data. | GAO-16-329SP

Of the 37 programs that decreased their total acquisition cost over the past year,

- 29 did so by finding efficiencies in the program and not by changing procurement quantities resulting in total cost decreases of $9.5 billion;
- 6 reduced their planned procurement quantities thereby reducing overall cost by $8.1 billion; and
- 2 programs—the Evolved Expendable Launch Vehicle and the Ship-to-Shore Connector Amphibious Craft—were able to reduce their overall cost by $1.7 billion while increasing their planned procurement quantities.

In contrast, 42 programs reported total acquisition cost increases over the past year. Of these,

- 27 reported cost increases due to inefficiencies in the program rather than a change in procurement quantities resulting in a total cost increase of almost $2.9 billion;
- 15 increased their planned procurement quantities resulting in a cost increase of almost $14 billion.

6. **Thirty-eight programs in the portfolio gained buying power during the past year resulting in a gain of $10.7 billion. There are a few programs that gain or lose buying power year after year; 6 programs in our analysis report such gains or losses.** As can be seen from the preceding discussion of individual cost increases and decreases, to better understand the changes in the portfolio's total cost over the past year, the effect of changes in quantity on individual programs must be analyzed and understood. In general, buying power can be defined as the amount of goods or services that can be purchased given a specified level of funding. To determine changes in buying power, the effects of quantity changes must be isolated from other factors that affect cost. For example, a program's cost can increase solely because of additional quantities. While that does represent a cost increase, it does not necessarily indicate acquisition problems or a loss of buying power. Alternatively a program's cost can decrease due to a reduction in quantity and may still experience a buying power gain or loss.

   According to our calculation of cost changes attributable to quantity changes we would have expected the portfolio to increase by $4.7 billion in procurement costs. Instead, procurement costs for the

portfolio have decreased by $6 billion over the past year, indicating that programs found efficiencies in other areas to offset the cost of additional quantities and the portfolio overall realized a buying power gain.[11] Our calculation of how programs' cost and quantity changes affected their buying power is presented in table 4.

Table 4: Buying Power Analysis for the 2015 Portfolio
Fiscal year 2016 dollars (in billions)

	Number of programs	GAO-calculated cost change attributable to quantity changes	Actual procurement cost change	GAO calculated cost change not attributable to quantity changes
Programs that gained buying power	38	$10.6	-$5.4	-$16.0
Procurement cost decreased with no quantity change	26	$0.0	-$10.6	-$10.6
Quantity increased with less cost increase than anticipated	11	$10.6	$5.9	-$4.7
Quantity decreased with more cost decrease than anticipated	1	-$.06	-$0.7	-$0.7
Programs that lost buying power	**35**	**-$4.2**	**$1.1**	**$5.3**
Procurement cost increased with no quantity change	25	$0.0	$2.0	$2.0
Quantity increased with more cost increase than anticipated	6	$4.9	$5.5	$0.6
Quantity decreased with less cost decrease than anticipated	4	-$9.1	-$6.3	$2.8
Programs with no change in buying power	5	$0.0	$0.0	$0.0
Program eliminated procurement	**1**	**-$1.7**	**-$1.7**	**$0.0**
Portfolio totals	**79**	**$4.7**	**-$6.0**	**-$10.7**

Source: GAO analysis of DOD data. | GAO-16-329SP

Note: Some numbers may not sum due to rounding.

Our analysis shows that 38 programs increased their buying power in the past year and reduced procurement costs by a total of $5.4 billion. This total is the net amount of cost change given increases and decreases due to other program efficiencies. Twenty-six of these 38 programs decreased procurement costs with no change in their procurement quantity indicating that they found efficiencies elsewhere. Some of these programs reported identifying significant realized and expected "should-cost" savings that resulted in a reduction of procurement cost or offset the cost of additional quantities.

[11] A description of the calculation used can be found in appendix I.

Eleven programs are buying additional quantities at lower prices. In other words, their planned procurement quantities increased but the corresponding procurement cost did not increase in kind or was offset by other efficiencies. For example, the SSN 774 Virginia Class Submarine procured two additional submarines with a lower than expected procurement cost increase. Our analysis indicates that if only the quantity increase is considered, the program's procurement costs should have risen by $5.2 billion. Instead, the program realized a buying power gain, due to program cost efficiencies and realized reductions of $390 million.

Thirty-five programs lost buying power in the past year with actual procurement cost increases of $1.1 billion. By our calculations, the net result of quantity changes on these programs should have resulted in a $4.2 billion cost decrease due to reductions in quantities on 4 of these 35 programs. This means that procurement cost increases not related to quantity changes generated $5.3 billion in additional costs and a net buying power loss. Contributing to this were 25 programs that lost buying power as their procurement costs increased with no change in quantities, an indication of inefficiencies within these programs. For example, the CH-47F Improved Cargo Helicopter program lost buying power as it experienced a procurement cost increase of $39 million over the past year with no change in its planned procurement quantity. Six other programs increased their planned procurement quantities but incurred a higher than expected procurement cost increase, indicating that they lost efficiencies elsewhere. The remaining 4 programs reported decreases in their initial quantities; however, the cost reductions on these programs are less than expected by our calculations.

In addition, there are a handful of individual programs that gain or lose buying power consistently:

- Three programs—Tactical Tomahawk, MQ-4C Triton Unmanned Aircraft System, and C-5 Reliability Enhancement and Re-engineering Program—experienced gains in buying power each year over the past 5 years. Tactical Tomahawk changed its quantities in 3 of the past 5 years but quantities for the other programs did not change.

- Three programs—CH-53K Heavy Lift Replacement Helicopter, DDG 1000 Zumwalt Class Destroyer, and Joint Precision Approach and Landing System—lost buying power in each of the past 5 years. These programs generally had successive years of

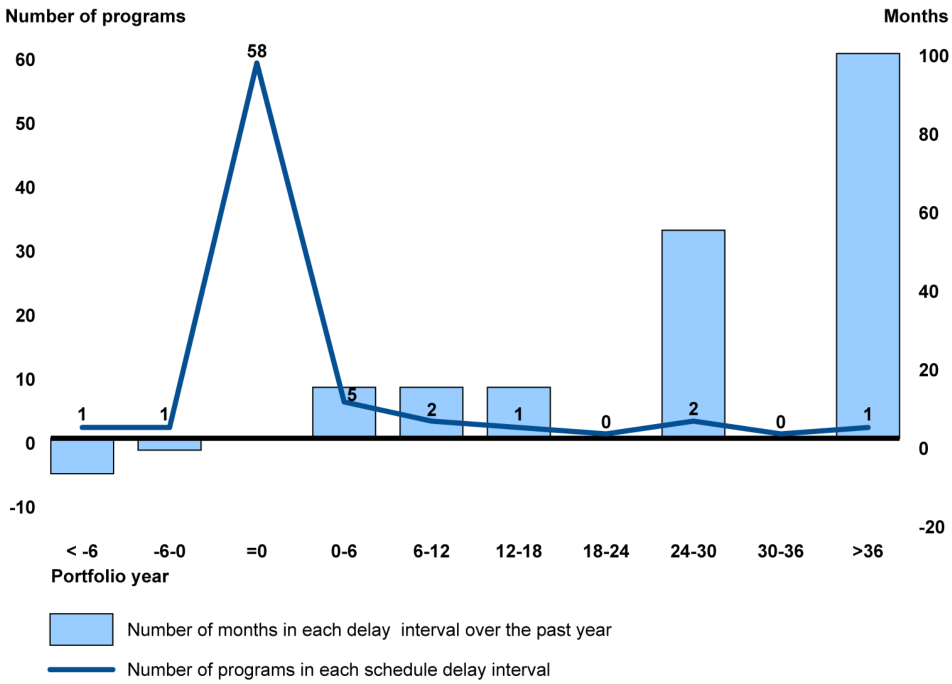
procurement cost increases with only minimal quantity changes that were outweighed by other inefficiencies.

Of the programs that have consistently lost buying power over the past 5 years, most have also had schedule delays longer than those that gained buying power consistently.

7. **Schedule delays over the past year in 11 of the 79 programs contributed to the portfolio's overall delay of 2.4 months. The Airborne Maritime/Fixed Station radio system experienced the largest delay at more than 8 years, which disproportionately affected the portfolio.** Thirteen programs in the current portfolio reported a schedule change over the past year, 11 of which were delays. The average 2.4 month schedule increase for 2015 is the result of changes reported by all the programs in the current portfolio. If the effect of the Airborne Maritime/Fixed Station radio system's delay is removed from the analysis, the average schedule increase for 2015 is 1.1 months, similar to what we reported in our last assessment.[12] Figure 4 below shows the schedule changes over the past year.

[12]GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, GAO-15-342SP (Washington, D.C.: Mar. 12, 2015).

Figure 4: Distribution of the 1-year Change in Delivery of Initial Operational Capability within the 2015 Portfolio



Source: GAO analysis of DOD data. | GAO-16-329SP

Six programs reported schedule delays of more than 6 months over the past year. For example, due to an overall Joint Tactical Radio System reorganization, the Airborne Maritime/Fixed Station radio system was restructured in 2012. The program had not been reporting an initial operational capability delivery date until this past year when it reported a delay of 98 months, more than 8 years, from its initial estimate. In another case, the Next Generation Operational Control System reported a delay of 27 months over the past year. Due to issues with the integration and testing of its initial block of capability and the concurrent systems engineering approach for subsequent blocks, the program reported delays to its delivery of initial capability and its production decision dates. Similarly, the DDG 1000 Zumwalt Class Destroyer reported a delay of 26 months over the past year due to technical risk, shipyard performance, and shipyard workforce constraints. Another 5 of the 11 programs reported schedule delays of less than six months over the past year.

Two programs—the B-2 Extremely High Frequency Satellite Communications and Computer Increment 1 and Space Fence Ground-Based Radar System Increment 1—reported dates for delivery of initial operational capability 3 and 9 months earlier than expected. The B-2 Extremely High Frequency Satellite Communications and Computer Increment 1 date was revised to reflect the actual delivery of capability and the Space Fence program's change is the result of a schedule revision post-contract award.

8. **Sixteen programs in production reported development cost growth over the past year even though production is a phase of the acquisition cycle which should have minimal development cost growth. This represents concurrency, albeit for differing reasons, and is a contributor to cost growth.** The 16 programs in our assessment that report development cost increases of 2 percent or more over the past year account for $3.3 billion in development cost growth. These programs are in production, a phase of the acquisition cycle which should have minimal development cost growth. On average, these 16 programs have been in the portfolio more than 16 years and 56 percent of them have already achieved their initial operating capability. Table 5 shows the extent and causes of the development cost growth on these programs.

Table 5: Programs with the Largest Development Cost Percentage Increases over the Past Year
Fiscal year 2016 dollars (in millions)

Program	Percentage increase in development cost over the past year	Amount of development cost growth over the past year	Initial capability achieved	Primary cause for development cost increase
AIM-9X Block II Air-to-Air Missile	45%	$172	No	Deficiency
MQ-8 Fire Scout	36	325	Yes	Unplanned capability
Evolved Expendable Launch Vehicle	21	528	Yes	Unplanned capability
Navy Multiband Terminal	18	135	Yes	Unplanned capability
Patriot Advanced Capability-3 Missile Segment Enhancement	9	80	No	Unplanned capability
Family of Advanced Beyond-Line-of-Sight Terminals	9	215	No	Deficiency
DDG 51Arleigh Burke Class Guided Missile Destroyer	6	364	Yes	Unplanned capability
Global Positioning System III	6	180	NA	Deficiency
Next Generation Operational Control System	5	190	No	Deficiency
LHA 6 America Class Amphibious Assault Ship	4	17	No	Unplanned capability
Littoral Combat Ship Mission Packages	4	93	No	Deficiency
EA-18G Growler Aircraft	4	85	Yes	Unplanned capability

Program	Percentage increase in development cost over the past year	Amount of development cost growth over the past year	Initial capability achieved	Primary cause for development cost increase
AIM-120 Advanced Medium Range Air-to-Air Missile	4	157	Yes	Unplanned capability
V-22 Osprey Joint Services Advanced Vertical Lift Aircraft	3	484	Yes	Unplanned capability
Multifunctional Information Distribution System	3	69	Yes	Unplanned capability
Cooperative Engagement Capability	3	109	Yes	Unplanned capability

Source: GAO analysis of DOD data. | GAO-16-329SP

Development cost increases on these programs are generally due to one of two factors:

- Five of the 16 needed additional funding to correct for deficiencies found in testing. For example, the AIM-9X Block II program reported a development cost increase of 45 percent due to deficiencies found during operational testing.

- Eleven of the 16 added unplanned capability to a program's baseline. Increasing the capabilities of a program beyond the established requirements adds cost and potential risk to mature weapon systems already in production. Three of the four largest development percentage increases are due to increases in capability. Adding capability while in production leads to concurrency in development and production and can lead to instability. In some cases the added capability may be warranted whereas in others it might be best to develop and deliver a new capability incrementally, which could be part of a new major defense acquisition program, rather than as an add-in to a current program, as recommended by best practices for cost estimating.[13] Adding capability to existing cost baselines can also create oversight challenges as it becomes difficult to differentiate the reasons for cost growth.

Other Observations

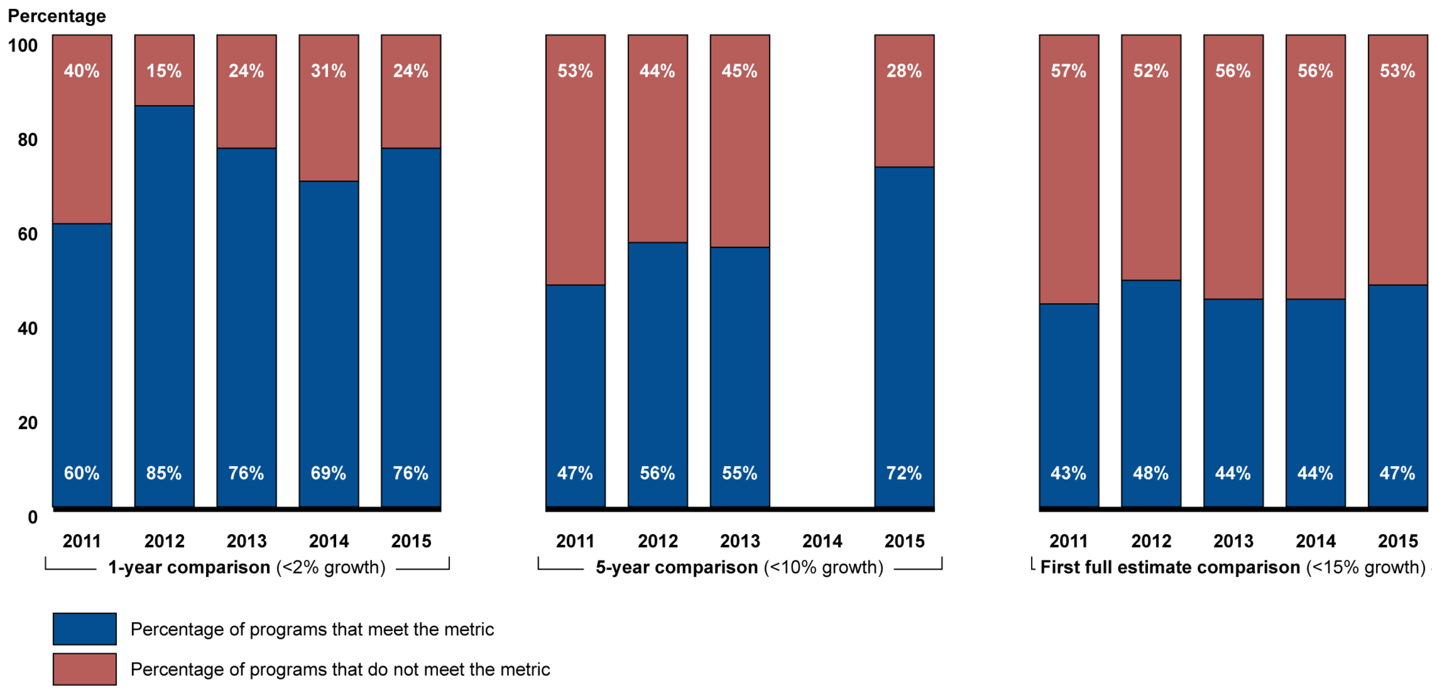
9. As measured against the metrics discussed with the Office of Management and Budget (OMB) and DOD, more programs meet each metric for cost change than previous assessments. Most notably, 72 percent of programs meet the threshold for less than

[13]GAO, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP (Washington, D.C.: Mar. 2, 2009).

10 percent growth over the past 5 years compared to the 2013 portfolio in which 55 percent of programs met this metric. Seventy-six percent meet the threshold for less than 2 percent growth in the past year. Forty-seven percent meet the threshold for less than 15 percent cost growth since first full estimates. In December 2008, GAO, OMB, and DOD discussed a set of outcome metrics and goals to measure program cost performance over time. The metrics are intended to measure cost performance on a percentage basis over three defined periods: the preceding year, the preceding 5 years, and since first full estimates were established.[14] We have reported on these outcomes since 2012 and figure 5 shows how the performance of the current portfolio compares to our prior assessments.

[14]DOD no longer supports the use of these metrics. We continue to believe that they have value.

Figure 5: Comparison of the Cost Performance of DOD's 2011-2015 Portfolios



Source: GAO analysis of DOD data. | GAO-16-329SP

Note: For the 2014 Portfolio we did not calculate a 5-year comparison as there were no December 2008 SARs issued.

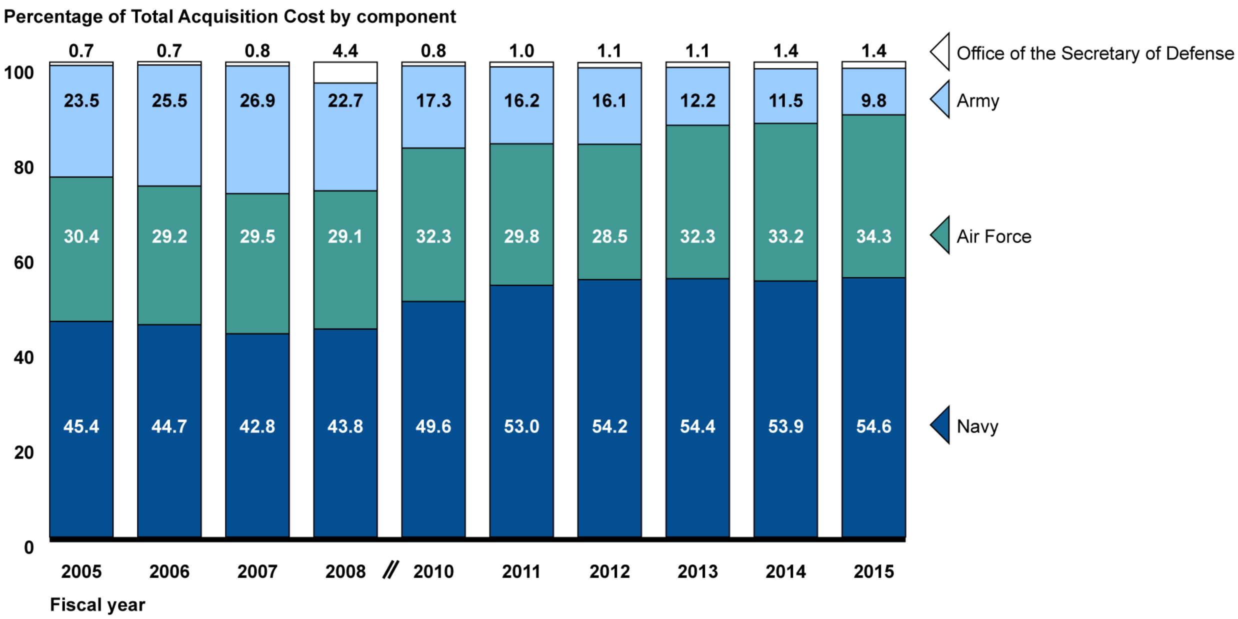
Seventy-two percent of programs in the current portfolio kept their cost growth under 10 percent over the past 5 years. This is a significant improvement compared to the 2013 portfolio, the last time we assessed this metric. As this metric measures programs' cost growth over the past 5 years, the improvement in the number of programs meeting this metric may be due to programs started since 2010 and the department's implementation of WSARA and the "Better Buying Power" initiatives. Programs started before 2010 have experienced over $469 billion in total acquisition cost growth since their first full estimates whereas programs started after 2010 have experienced over $580 million in decreases. However, these programs have only recently begun development and will need continued oversight to ensure they do not increase in cost in the future.

Seventy-six percent of programs in the 2015 portfolio meet the one year cost performance metric by limiting total acquisition cost growth to less than 2 percent, and 47 percent of programs meet the threshold

for less than 15 percent cost growth since first full estimates. Although a larger share of programs is meeting the 1-year metric than in our last assessment, performance against the first full estimate cost growth threshold is relatively unchanged, remaining less than 50 percent.

10. **Army programs' percentage of the total cost of the major defense acquisition program portfolio is the smallest of the services and has been decreasing since 2007. The percentage attributable to the Navy and Air Force programs' have been increasing since 2007 and 2012 respectively. Navy programs account for almost 55 percent of the 2015 total estimated acquisition cost.** The 79 programs in the current portfolio include three "joint" or DOD-wide programs—the F-35 Joint Strike Fighter, the Joint Light Tactical Vehicle, and Chemical Demilitarization—15 Army programs, 26 Air Force programs, and 35 Navy programs. The Army accounts for almost 10 percent, the Air Force accounts for over 34 percent, and the Navy accounts for almost 55 percent of the portfolio's total acquisition cost in 2015, including the service-specific funding within joint programs. Since 2005, the Army's portion of the portfolio has decreased, the Air Force's portion has increased slightly, and the Navy's portion has increased to its current level of 55 percent from a low of 43 percent in 2007. Figure 6 shows each service's portion of the portfolio's total acquisition cost since 2005.

Figure 6: Services' Percentage of the Portfolio's Total Acquisition Cost, 2005-2015



Source: GAO analysis of DOD data. | GAO-16-329SP

In a constrained funding environment, unforeseen cost growth limits investment choices within DOD. The Navy has historically had more programs than the Air Force and Army. Currently, the Navy has over 30 programs in the portfolio, while the Army has 16 programs including the Joint Light Tactical Vehicle. When looking at total cost, the Navy currently accounts for $785 billion of the $1.4 trillion total acquisition cost. This cost can be expected to grow as the Navy does not include all of the anticipated ships of a class in the Selected Acquisition Reports (SAR) we use to assess programs. For example, while there may be up to 11 Ford–class aircraft carriers delivered, the

current cost reporting only accounts for 3. We have reported on many of the Navy's programs and their acquisition challenges.[15]

11. **The equity prices of the contractors delivering the 10 costliest programs have performed well relative to broad-based market indices, indicating that investors expect these firms to remain profitable well into the future.** Five publicly-traded defense contractors are developing and delivering the 10 largest DOD programs in the 2015 portfolio. The equity prices—a stock price-based indicator of investor expectations of future earnings over many years—for these contractors over the past decade has increased at a rate that outperformed broad-based indices for markets as a whole, as well as narrower indices covering similar sectors of the economy.[16] This indicates that investors expect the performance of these companies to be particularly strong for some time to come. Strong equity performance among these contractors could be driven by a number of factors and is not necessarily related to the financial condition of major acquisition programs.

[15]GAO, *Ford Class Aircraft Carrier: Poor Outcomes Are the Predictable Consequences of the Prevalent Acquisition Culture,* GAO-16-84T (Washington, D.C.: Oct. 1, 2015); *Ford-Class Aircraft Carrier: Congress Should Consider Revising Cost Cap Legislation to Include All Construction Costs,* GAO-15-22 (Washington, D.C.: Nov. 20, 2014); *Littoral Combat Ship: Navy Complied with Regulations in Accepting Two Lead Ships, but Quality Problems Persisted after Delivery*, GAO-14-827 (Washington, D.C.: Sept. 25, 2014); *Navy Shipbuilding: Significant Investments in the Littoral Combat Ship Continue Amid Substantial Unknowns about Capabilities, Use, and Cost*, GAO-13-530 (Washington, D.C.: July 22, 2013); *Arleigh Burke Destroyers: Additional Analysis and Oversight Required to Support the Navy's Future Surface Combatant Plans*, GAO-12-113 (Washington, D.C.: Jan. 24, 2012); *V-22 Osprey Aircraft: Assessments Needed to Address Operational and Cost Concerns to Define Future Investments*, GAO-09-692T (Washington, D.C.: June 23, 2009); *Defense Acquisitions: Realistic Business Cases Needed to Execute Navy Shipbuilding Programs*, GAO-07-943T (Washington, D.C. July 24, 2007); *Multiyear Procurement Authority for the Virginia Class Submarine Program*, GAO-03-895R: (Washington, D.C.: June 23, 2003).

[16]Indices used are based on Standard & Poor's Global Industry Classification System.

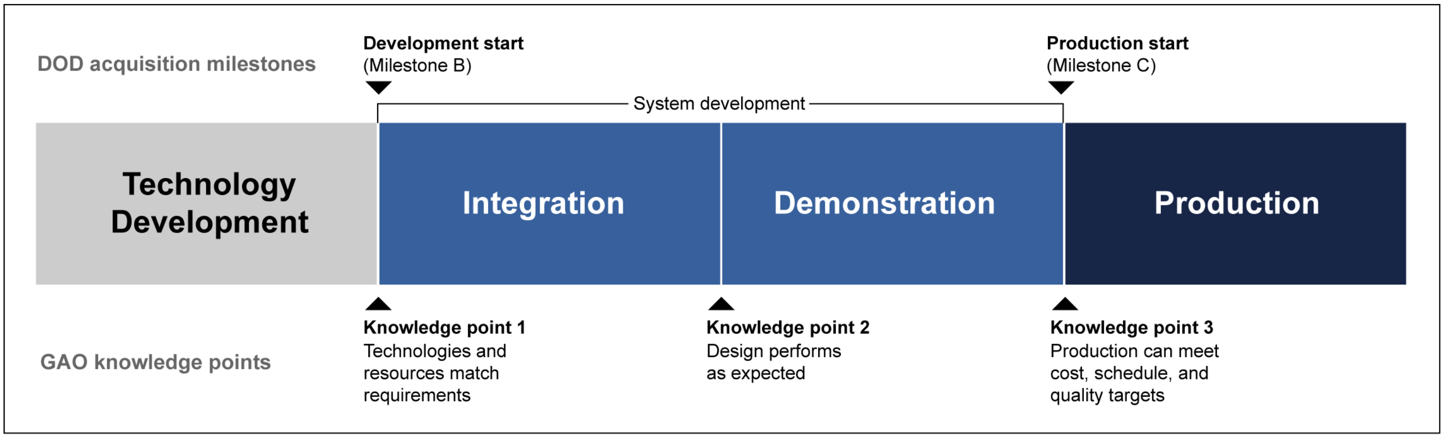
Observations from Our Assessment of Knowledge Attained by Programs at Key Junctures

Our analysis found that while a few programs are using knowledge-based approaches to reduce their acquisition risk, implementation of these approaches across the portfolio has been uneven. For example, programs that recently began system development demonstrated some best practices—such as holding a preliminary design review prior to committing resources. Others, however, are carrying technology risk well into system development, failing to demonstrate designs through prototyping, or proceeding into production before ensuring manufacturing processes are under control and testing is complete.

Our body of work has shown that positive acquisition outcomes require the use of a knowledge-based approach to product development that demonstrates high levels of knowledge before significant commitments are made. In essence, knowledge supplants risk over time. In our past work examining weapon acquisition and best practices for product development, we have found that leading commercial firms and successful DOD programs pursue an acquisition approach that is anchored in knowledge, whereby high levels of product knowledge are demonstrated at critical points in the acquisition process. This work led to multiple recommendations that DOD generally or partially agreed with and has made progress in implementing.[17] On the basis of this work, we have identified three key knowledge points during the acquisition cycle—development start, system-level critical design review, and production start—at which programs need to demonstrate critical levels of knowledge to proceed. Figure 7 aligns the acquisition milestones described in DOD's primary acquisition policy with these knowledge points. In this report, we refer to DOD's engineering and manufacturing development phase as system development. Production start typically refers to a program's entry into low-rate initial production.

[17] GAO, *Best Practices: DOD Can Achieve Better Outcomes by Standardizing the Way Manufacturing Risks Are Managed*, GAO-10-439 (Washington, D.C.: Apr. 22, 2010); *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*, GAO-09-322 (Washington, D.C.: May 13, 2009); *Defense Acquisitions: A Knowledge-Based Funding Approach Could Improve Major Weapon System Program Outcomes*, GAO-08-619 (Washington, D.C.: July 2, 2008); *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, GAO-02-701 (Washington, D.C.: July 15, 2002); *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001); and *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999).

Figure 7: DOD's Acquisition Cycle and GAO Knowledge Points



Source: GAO. | GAO-16-329SP

As our prior work has shown, the building of knowledge consists of information that should be gathered at three critical points over the course of a program.

Knowledge point 1: Resources and requirements match. Achieving a high level of technology maturity by the start of system development is one of several important indicators of whether this match has been made. This means that the technologies needed to meet essential product requirements have been demonstrated to work in a relevant environment. In addition, the developer should complete a series of systems engineering reviews culminating in a preliminary design of the product that shows the design is feasible. Constraining the development phase of a program to 5 or 6 years is also recommended because it aligns with DOD's budget planning process and fosters the negotiation of trade-offs in requirements and technologies. For shipbuilding programs, critical technologies should be matured into actual sub-system prototypes and successfully demonstrated in an operational environment before a contract is awarded for the detailed design of a new ship.

Knowledge point 2: Product design is stable. This point occurs when a program determines that a product's design will meet customer requirements, as well as cost, schedule, and reliability targets. A best practice is to achieve design stability at the system-level critical design review, usually held midway through system development. Completion of at least 90 percent of engineering drawings at this point provides tangible

evidence that the product's design is stable, and a prototype demonstration shows that the design is capable of meeting performance requirements. Shipbuilding programs should demonstrate design stability by completing 100 percent of the basic and functional drawings, as well as the three-dimensional product model by the start of construction for a new ship. Programs can also improve the stability of their design by conducting reliability growth testing and completing failure modes and effects analyses so fixes can be incorporated before production begins. At this point, programs should also begin preparing for production by identifying manufacturing risks, key product characteristics, and critical manufacturing processes.

Knowledge point 3: Manufacturing processes are mature. This point is achieved when it has been demonstrated that the developer can manufacture the product within cost, schedule, and quality targets. A best practice is to ensure that all critical manufacturing processes are in statistical control—that is, they are repeatable, sustainable, and capable of consistently producing parts within the product's quality tolerances and standards—at the start of production. Demonstrating critical processes on a pilot production line is an important initial step in this effort. In addition, production and postproduction costs are minimized when a fully integrated, capable production-representative prototype is demonstrated to show that the system will work as intended in a reliable manner before committing to production. We did not assess shipbuilding programs for this knowledge point due to differences in the production processes used to build ships.

Knowledge in these three areas builds over time. Our prior work on knowledge-based approaches shows that a knowledge deficit early in a program can cascade through design and production, leaving decision makers with less knowledge to support decisions about when and how to best move into subsequent acquisition phases that commit more budgetary resources. Demonstrating technology maturity is a prerequisite for moving forward into system development, during which time the focus should be on design and integration. A stable and mature design is also a prerequisite for moving forward into production, where the focus should be on efficient manufacturing. Additional details about key practices at each of the knowledge points can be found in appendix IV.

For this report, we assessed the knowledge attained at key junctures in the acquisition process for 43 current programs, most of which are in development or early production.[18] Not all programs included in our review of knowledge-based practices provided information for every knowledge point and some had not reached all of the knowledge points—development start, design review, and production start—at the time of this assessment. We also reviewed the knowledge that 12 future major defense acquisition programs identified by DOD expect to attain when they start system development in the coming years.[19]

Our analysis of the data from these current and future programs allows us to make the following three observations.

Knowledge Point Observations

1. Of the seven programs that began, or are planning to begin, system development during our assessment period, none have demonstrated a full match between resources and requirements. One program plans to enter system development with immature technologies whereas the rest will have technologies approaching full maturity. Five of the seven programs completed a preliminary design review before development start. Two did not conduct all of the early system engineering reviews recommended by best practices. All but one program plan to constrain their development phase to 6 six years or less. The implementation of best practices by these programs is better from what we have previously observed.
2. Of the five programs that held, or are planning to hold, a critical design review during our assessment period, two met all of the best practices. Two of the programs have not fully demonstrated mature technologies, but all plan to release at least 90 percent of drawings. Three of 5 programs plan to test a system-level integrated prototype to determine the effectiveness of their designs. This is an improvement over our previous assessment when none of the programs implemented all of the best practices.
3. Of the five programs that held or plan to hold a production decision during our assessment period, one met all of the best practices including demonstrating that their manufacturing process capabilities are in control.[a] Three of the programs do not plan to test a production-representative prototype before making a production decision, but all state that they have demonstrated processes on a pilot production line. Overall implementation is better than what we have observed in the past.

Source: GAO analysis of DOD data. | GAO-16-329SP

[a]In DOD's technical comments on a draft of this report, we were informed that the MQ-4C Triton's production decision has been delayed to May 2016.

[18]Because knowledge points and best practices differ for shipbuilding programs, we exclude the five shipbuilding programs from parts of our analysis at each of the three knowledge points, for more information see appendix I.

[19]Information for these programs was collected from two data collection instruments distributed to program officials. See the "Analysis of Selected DOD Programs Using Knowledge-Based Criteria" section of appendix I for more information.

1. **The seven programs that started system development, or had plans to do so in 2015, have knowledge deficits which undermine the foundation needed to avoid future cost and schedule problems. One program plans to begin system development with immature technologies and none of the seven programs demonstrated critical technologies in an operational environment. Five programs conducted all systems engineering reviews, including a preliminary design review, before entering system development while one program conducted one of these reviews. Six programs plan to limit their development phase to 6 years or less whereas one has yet to determine the length of its development phase.** Our prior work shows that the most critical juncture in any major defense acquisition is the decision to start system development, a point at which knowledge-based acquisition practices recommend having a match between what DOD wants in a weapon system, as defined by its requirements, and the mature technologies, funding, schedule, and other resources needed to develop that system.[20] Our current assessment shows that the implementation of best practices by the 7 programs starting development is better from what we have previously observed. Figure 8 shows the extent to which recommended acquisition practices for knowledge point 1 have been implemented for the seven programs that recently started system development or plan to do so in early 2016: Amphibious Combat Vehicle (ACV), B-2 Defensive Management System Modernization (B-2 DMS-M), Common Infrared Countermeasures (CIRCM), Joint Air-to-Ground Missile (JAGM), Military GPS User Equipment Increment 1 (MGUE), Next Generation Jammer Increment 1 (NGJ Inc 1), and Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1)—as well as the other 36 current programs we assessed which accomplished this knowledge point previously.

[20]GAO, *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999) and GAO, *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001).

Figure 8: Implementation of Knowledge-Based Practices for Programs at System Development Start

Knowledge-based practices at system development start	ACV	B-2 DMS-M	CIRCM	JAGM	MGUE	NGJ Inc. 1	OASuW Inc. 1	Other 36 programs ●	Other 36 programs ○	Other 36 programs ––
Demonstrate all critical technologies in a relevant environment	●	●	●	●	●	●	○	20	8	8
Demonstrate all critical technologies in an operational environment	○	○	○	○	○	○	○	3	23	10
Complete system functional review and system requirements review before system development start	○	●	●	●	●	●	●	10	25	1
Completed preliminary design review before system development start	○	●	●	○	●	●	●	13	22	1
Constrain system development phase to 6 years or less	●	●	●	●	––	●	●	22	6	8

● Practice implemented

○ Practice not implemented

––– Practice not applicable or information not available per the program office response

ACV - Amphibious Combat Vehicle
B-2 DMS-M - B-2 Defensive Management System Modernization
CIRCM - Common Infrared Countermeasures
JAGM - Joint Air-to-Ground Missile
MGUE - Military GPS User Equipment Increment 1
NGJ Inc. 1 - Next Generation Jammer Increment 1
OASuW Inc. 1 - Offensive Anti-Surface Warfare Increment 1

Source: GAO analysis of DOD data. | GAO-16-329SP

Demonstrate Technology Maturity

We assessed to what level programs starting system development matured their critical technologies. Federal statute requires that programs generally obtain a certification stating that technologies have been demonstrated in a relevant environment.[21] However, knowledge-based acquisition practices recommend that programs fully mature technologies by demonstrating them in an operational—or realistic—environment prior to starting system development. Demonstrating technologies in an operational environment is a better indicator of whether a program has achieved a resource and requirements match as it demonstrates the technologies' form, fit, and

[21]Demonstration in a relevant environment is Technology Readiness Level (TRL) 6. Demonstration in an operational environment is TRL 7. See appendix V for detailed descriptions of TRLs. In addition, a major defense acquisition program generally may not receive approval for development start until the milestone decision authority certifies that the technology in the program has been demonstrated in a relevant environment. 10 U.S.C. § 2366b(a)(3)(D). Under certain circumstances this requirement may be waived.

function as well as the effect of the intended environment on those technologies.

One program at development start—OASuW Inc 1—does not plan to demonstrate its critical technologies in even a relevant environment. OASuW Inc 1 is a Navy program initiated in 2013 in response to an urgent operational need and will be developed using an accelerated acquisition strategy. While the program plans to leverage previous technology demonstration efforts, it also plans to begin development in February 2016 with immature technologies. Currently the program has six critical technologies whose basic components have been integrated and tested in a lab environment. The components may be representative of a technically feasible approach but they have not been matured to the point of demonstrating form, fit, and function. Beginning development with low technology maturity adds significant risk to the program's accelerated acquisition.

We found that none of the seven programs that began or were planning to begin system development in 2015 will have fully mature technologies. Fully mature technologies require that the program demonstrate their technologies in an operational environment. For example, the Navy assessed the ACV's critical technologies as fully mature based on a technology readiness assessment approved in December 2014. This assessment was based on the non-developmental nature of the vehicles, the use of mature technology for modifications, and tests and demonstrations of prototype vehicles done for another program, the Marine Personnel Carrier. In contrast, we determined that one of the program's two critical technologies had not been tested in an operational environment, as it was not tested at sea, and therefore was not fully mature.[22]

Of the remaining 36 programs, 3 reported that all of their critical technologies were demonstrated in an operational environment when they began development, while 23 programs reported that their technologies had not reached full maturity. Of all of the programs in our assessment, just 7 percent began system development with fully mature technologies.

[22]GAO, *Amphibious Combat Vehicle: Some Acquisition Activities Demonstrate Best Practices; Attainment of Amphibious Capability to be Determined*, GAO-16-22 (Washington, D.C.: October 28, 2015).

We examined whether programs started before or after 2010 are meeting best practices and their subsequent levels of cost growth. Of the 36 programs we assessed for technology readiness, 20 began system development before 2010, 15 after, and one did not hold a system development start. Eight of the 20 programs began development with immature technologies. Since they began system development they have collectively realized almost $32 billion in development cost growth. In contrast, the seven programs that started development with fully mature technologies before 2010 have realized just $286 million, in development cost growth. The remaining 5 programs did not report on the technology maturity at this point.

Complete Systems Engineering Reviews before Development Start

Knowledge-based acquisition practices recommend that programs hold systems engineering events before the start of system development:

- A system requirements review ensures that requirements have been properly identified and that there is a mutual understanding between the government and the contractor.
- A system functional review establishes a baseline for the planned system.
- A preliminary design review establishes that requirements are defined and feasible, and that the proposed design can meet those requirements within cost, schedule, and other system constraints.

We found that six programs that began or plan to begin system development, completed system functional and system requirements reviews prior to starting system development and one did not. This is an improvement over the other 36 programs we assessed.

WSARA established a statutory requirement to conduct a preliminary design review prior to entering system development.[23] Among the seven programs that started system development in 2015, or planned

[23]Pub. L. No. 111-23, § 205(a). A major defense acquisition program may not receive milestone B approval until the program has held a preliminary design review and the milestone decision authority has conducted a formal post-preliminary design review assessment and certified on the basis of such assessment that the program demonstrates a high likelihood of accomplishing its intended mission unless a waiver is properly granted by the milestone decision authority. 10 U.S.C. §§ 2366b(a)(2), (d)(1).

to in early 2016, five of them conducted a preliminary design review before beginning system development. The other two programs received a waiver to this requirement and expect to conduct this review after their system development start. Thirteen of the other 36 programs held a preliminary design review before the start of system development. Nearly 60 percent of programs that began development since 2010 are implementing this practice compared to 25 percent of programs that began development before 2010, an improvement over our prior assessment.

Constrain System Development Phase to 6 years or Less

Knowledge-based acquisition practices also recommend that a program constrain the system development phase to 6 years or less. Our review of the seven programs that began, or plan to begin, system development during our review period found that six of the seven currently plan to do so. One program in our assessment has not determined when it will end system development and enter production.

For the remaining 36 programs we assessed, 22 planned to limit their system development phase to six years or less at the time they started system development.[24] Plans to constrain the development phase at the start of system development are not always successful. For example, 5 of the programs we assessed took longer to reach production than the six years or less they originally planned. One of these programs began development with immature technologies and 4 had technologies approaching maturity. As a group, they reported approximately $2.1 billion in development cost growth from first full estimates. Sixteen programs plan to enter production in the future, but additional delays may occur, especially as a number of these programs have not implemented all of the best practices for system development.

[24]We did not assess shipbuilding programs against this recommended practice to limit the development phase, as their development cycles do not align in a manner consistent with other programs.

Begin Future Programs with Adequate Knowledge

As part of our analysis, we also assessed 12 programs scheduled to start system development and become major defense acquisition programs in the near future. The greatest point of leverage to ensure a program's success is at the start of a new program. At this point, decision makers can ensure that new programs implement best practices and exhibit desirable principles before they are approved and funded. These programs provided information on the knowledge they planned to obtain and the best practices they intend to implement before system development start. Five of the 12 identified critical technologies and their anticipated maturity levels expected at system development start. Two programs—the Unmanned Carrier-Launched Airborne Surveillance and Strike system and the Fleet Replenishment Oiler—reported that they expect their critical technologies to be fully mature. Table 6 shows this and that the remaining programs reported that their critical technologies would not be fully mature or have not been identified and one program's technology maturity is to be determined at the time of their system development start.

Table 6: Projected Implementation of Knowledge-Based Practices for Future Programs

	Development start	Projected to demonstrate all critical technologies in an operational environment	Projected to complete all systems engineering reviews	Plan to constrain system development
Fleet Replenishment Oiler	06/2016	●	O	●
Indirect Fire Protection Capability, Increment 2	06/2016		●	●
F-15 Eagle Passive/Active Warning and Survivability System	09/2016	O	●	●
Ohio-Class Replacement	09/2016		O	O
Presidential Aircraft Recapitalization	03/2017		O	O
P-8A Increment 3	06/2017		O	O
Unmanned Carrier-Launched Airborne Surveillance and Strike	06/2017	●	—-	O
Joint Surveillance Target Attack Radar System Recap	09/2017	—-	●	●
Improved Turbine Engine Program	06/2018	O	O	O
Amphibious Ship Replacement	09/2018		O	O
Advanced Pilot Training	12/2017		O	●
Weather Satellite Follow-On	12/2018	O	O	O

Legend
● Implementation planned
O No implementation planned
—- Practice to be determined
Critical technologies have not been identified per the program office response
Source: GAO analysis of DOD data. | GAO-16-329SP

Three of the 12 programs plan to conduct all of the recommended systems engineering reviews before development start, including a system functional review, a system requirements review, and a preliminary design review. Unlike the programs that held system development start in the past year, only four of the 12 future programs plan to hold a preliminary design review before the start of system development. While five of the 12 future programs currently plan to limit their system development phase to 6 years or less, these plans are preliminary and the programs are at risk of not satisfying all the knowledge-based practices we reviewed, leaving them at risk for cost and schedule growth.

If DOD decides to let these programs proceed without the knowledge required to achieve a requirements and resource match this will have larger implications than the expected outcomes on these programs. It sends a signal across the entire portfolio of current and future programs about what is acceptable in terms of following a knowledge-based acquisition approach. It is imperative that top decision makers ensure that new programs exhibit desirable principles that embody knowledge-based acquisition best practices before they are approved and funded at the start of system development, one of the key points in the acquisition cycle where discipline and accountability can be established and reinforced.

2. **Of the five programs that held, or are planning to hold, a critical design review during our assessment period, two met all of the best practices. Two of the programs have not demonstrated mature technologies, and all plan to release at least 90 percent of drawings. Three of 5 programs plan to test a system-level integrated prototype.** For this knowledge point in a program's acquisition, we assessed eight best practices to determine the extent to which programs are attaining the knowledge needed for a low risk acquisition. We found an improvement over our previous assessment in programs' implementation of best practices at their critical design review. We have previously reported that programs that hold their critical design review before achieving knowledge of a stable, demonstrated design also experience higher average costs and longer schedule delays. Figure 9 below outlines the implementation of this, as well as other, best practices among the programs we assessed.

Figure 9: Implementation of Knowledge-Based Practices for Programs at Critical Design Review

Knowledge-based practices at critical design review	ACV	AMDR	F-22 Inc. 3.2B	JAGM	Space Fence Inc. 1	Other 26 programs ●	Other 26 programs ○	Other 26 programs ——
Demonstrate all critical technologies in an operational environment	○	○	●	●	●	3	17	6
Release at least 90 percent of drawings or 100 percent of 3D zones	●	●	●	●	●	6	11	9
Test an early system-level integrated prototypes	○	●	●	●	○	1	20	5
Establish a reliability growth curve	●	●	●	●	●	17	6	3
Identify key product characteristics	●	●	●	●	●	23	0	3
Identify critical manufacturing processes	●	●	●	●	●	21	1	4
Conduct producibility assessments to identify manufacturing risks for key technologies	●	●	●	●	●	20	3	3
Complete failure modes and effects analysis	●	●	●	●	●	20	2	4

● Practice implemented

○ Practice not implemented

——— Practice not applicable or information not available per the program office response

ACV - Amphibious Combat Vehicle
AMDR - Air and Missile Defense Radar
F-22 Inc. 3.2B - F-22 Increment 3.2B Modernization
JAGM - Joint Air-to-Ground Missile
Space Fence Inc. 1 - Space Fence Ground-Based Radar System Increment 1

Source: GAO analysis of DOD data. | GAO-16-329SP

Demonstrate Technology Maturity

As product knowledge is cumulative, by the critical design review programs should have demonstrated critical technologies in an operational environment to ensure that the product can meet requirements. Failure to fully mature technologies prior to developing the system design can lead to redesign and cost and schedule growth if later discoveries in maturing technologies cause revisions.

Two programs do not plan to meet this best practice before completing their critical design review—ACV and AMDR. At the time of our review, the ACV program was scheduled to hold their critical design review in February, but this may be delayed due to a bid protest related to the development contract awards. The ACV program's current level of technology maturity is discussed in the previous section. AMDR has four critical technologies that have been demonstrated in a relevant, but not an operational environment, at the time of its critical design review.

To assess the effect of technology maturity on cost over time, we examined the 22 programs that started development 5 or more years ago and the level of their technology maturity at the time of their critical design review. Of these 22 programs, seven held their critical design review with immature technologies. These programs have realized an average of 74 percent, or $30 billion, in development cost growth over their initial cost estimates. Five of these programs are among those mentioned in the previous section that started system development with immature technologies with the addition of the M109A7 Family of Vehicles and Family of Advanced Beyond Line-of-Sight Terminals (FAB-T). In contrast, 9 programs had technologies approaching maturity or fully mature at their critical design review. These programs have realized an average of 33 percent, or $3.2 billion, in development cost growth, significantly less than the programs with immature technologies.

Demonstrate System Design Stability

Of the five programs that held, or plan to hold, their critical design review in 2015, all demonstrated or are expected to demonstrate design stability by releasing over 90 percent of their expected design drawings. This is an improvement over our prior assessment, in which both programs we assessed had not met this practice. When compared to the other 26 programs we assessed that held critical design reviews previously; 6 met this best practice, 11 had not, and 9 reported that the practice was not applicable.

Testing of a system-level integrated prototype is useful for demonstrating that a system will work as intended and can be built within cost and schedule. Two of the five programs that held, or plan to hold, their critical design review in 2015 did not, or will not, test a system-level integrated prototype prior to their design review—ACV and Space Fence, Inc 1. The ACV program reported completing this practice on another vehicle prototype. This vehicle was not the same design as the current ACV. As a result, GAO determined that this test did not meet the best practice as it did not include all of the key subsystems and components that will be in the ACV. The Space Fence Inc 1 program is developing a large, ground-based radar intended to track objects in Earth’s orbit. The program conducted its design review in June 2015 and completed at least 90 percent of its design drawings, but did not demonstrate its ability to meet performance requirements with testing of a system-level integrated prototype. The program plans to verify the design through testing on a fully configured prototype, with some production-representative elements, beginning in 2016 after the start of production.

We assessed 26 other programs that held a critical design review prior to 2015, and found that only one tested an early integrated prototype before its critical design review. For the other programs, early integrated prototype testing occurred or will occur after their critical design reviews. In some cases this testing will occur years later. We did not assess shipbuilding programs against this knowledge-based acquisition practice as testing early system prototypes in these programs may not be practical as these programs are not delivering large quantities. The limited use of this testing before design review among the programs we assessed shows no improvement from our prior assessments.

The five programs we assessed all plan to implement the last five knowledge-based practices shown in figure 9 to increase confidence in the stability of their product's design and its effect on production. This includes practices such as establishing a reliability growth curve and identifying key product characteristics in preparation for production activities. For the other 26 programs in this assessment that have already entered production, a majority of them reported using each of these practices.

Prepare for Production

3. **Of the five programs that held a production decision during our assessment period, one met all of the best practices, including demonstrating that their manufacturing process capabilities are in control. Three of the programs do not plan to test a production-representative prototype before making a production decision. All five state that they have demonstrated manufacturing processes on a pilot production line.** Capturing critical manufacturing knowledge before entering production ensures that a weapon system will work as intended and can be manufactured efficiently to meet cost, schedule, and quality targets. This knowledge can be captured through the use of various proactive methods, including the use of statistical process control data, pilot production lines, manufacturing readiness levels, and prototype testing. Overall we found better implementation of best practices at this point than what we have observed in the past. Figure 10 shows the extent to which programs that have held a production decision have implemented associated knowledge-based practices.

Figure 10: Implementation of Knowledge-Based Practices for Programs at Production Decision

Knowledge-based practices at production start	FAB-T	JLTV	MQ-4C[a]	SDBII	SSC	For the 11 non-shipbuilding programs that have reached this juncture[b] ●	○	——
Demonstrate all critical technologies in an operational environment	○	●	●	●	●	5	3	3
Release at least 90 percent of drawings or 100 percent of 3D zones	●	——	●	●	●	7	2	2
Demonstrate manufacturing process capabilities are in control	○	○	○	●	○	1	7	3
Demonstrate critical processes on a pilot production line	●	●	●	●	●	6	3	2
Test a production-representative prototype in its intended environment	○	●	○	●	○	4	7	0

● Practice implemented
○ Practice not implemented
——— Practice not applicable or information not available per the program office response

FAB-T - Family of Advanced Beyond Line-of-Sight Terminals
JLTV - Joint Light Tactical Vehicle
MQ-4C - MQ-4C Triton Unmanned Aircraft System
SDB II - Small Diameter Bomb Increment II
SSC - Ship to Shore Connector Amphibious Craft

Source: GAO analysis of DOD data. | GAO-16-329SP

[a]In DOD's technical comments on a draft of this report, we were informed that the MQ-4C Triton's production decision has been delayed to May 2016.

[b]Shipbuilding programs are not included in the assessment of best practices at production decision.

Demonstrate Manufacturing Processes Are in Control

Four of the five programs that have held recent production decisions did not demonstrate that their manufacturing process capabilities were in control. Small Diameter Bomb Increment II was the only program that satisfied this best practice. The programs not meeting this practice are tracking manufacturing readiness levels, although none of the programs reached the best practices recommended level of readiness. Our prior work has shown that capturing critical manufacturing knowledge before entering production helps ensure that the system will work as intended and will meet cost, schedule and quality targets. Of the remaining 11 non-ship programs we assessed that held production decisions prior to 2015, 1 provided data indicating that critical manufacturing processes were in control at the time of their production start.

Demonstrate Critical Processes on a Pilot Production Line

All of the programs that held a production decision over the past year demonstrated critical processes on a pilot production line. Of the programs we assessed, 17 plan to hold a production decision in the future and they all indicated that they intended to test a pilot production line before production start. Demonstrating critical processes on a pilot production line is an important initial step to ensure that all critical manufacturing processes are repeatable, sustainable, and capable of consistently producing parts within the product's quality tolerances and standards—at the start of production. Of the 11 non-ship programs that held productions decisions in the past, only six have demonstrated this best practice whereas two did not and three programs replied that the practice was not applicable.

Test a Production-Representative Prototype in Its Intended Environment

Our body of work on a knowledge-based approach shows that production and postproduction costs are also minimized when a fully integrated, production-representative prototype is demonstrated prior to the production decision as making design changes after production begins can be both costly and inefficient. Of the 5 programs that recently accomplished this milestone, 2 plan to meet this best practice and 3 do not. The three programs—FAB-T, MQ-4C, and SSC—plan to complete this testing from 10 months to over a year after their production decision dates. Of the 17 programs that plan to hold their production decision in the future, 9 report that they intend to test a fully configured prototype. In not conducting testing of production-representative prototypes prior to beginning manufacturing, programs risk discovering issues late in testing, which may trigger the need for expensive re-tooling of production lines and retrofitting of articles that have completed production. Of the 11 non-ship programs with production decisions in the past, four reported testing a production-representative prototype before this decision whereas seven did not.

Observations about DOD's Implementation of Key Acquisition Reform Initiatives and Program Concurrency

Over the past 5 years, increasing numbers of DOD programs have been implementing acquisition reform initiatives such as those in WSARA, and the "Better Buying Power" initiatives—many of which have been incorporated into the latest iteration of DOD's Instruction 5000.02.[25] The implementation of these initiatives has led to better acquisition outcomes on some programs. Nevertheless, DOD still faces challenges in fully implementing these reforms. Given the level of DOD's investment in major defense acquisition programs continued attention is warranted.

We focused our analysis on the aspects of WSARA and DOD's "Better Buying Power" initiatives that address program and portfolio affordability; cost growth controls; and the use of competition throughout the acquisition life-cycle. In addition, we reviewed programs' software development efforts to determine how they monitor and manage these efforts. We also assessed the amount of planned concurrency between developmental testing and production for current programs in the portfolio.

Overall, we found modest improvements across many of the areas we assessed. Compared to our previous assessment, similar proportions of programs have established affordability constraints, and more programs have attempted to determine and realize "should-cost" savings. However, the number of current and future programs using or planning to use competition measures does not show substantial improvement. Other risks to program performance persist as well, as high levels of concurrency between development testing and production may add risk to the portfolio.

Our analysis allows us to make the following five observations concerning key acquisition reform initiatives and program concurrency:

[25]Department of Defense Instruction 5000.02, *Operation of the Defense Acquisition System* (Jan. 2015) ("DOD Instruction 5000.02").

Acquisition Reform and Concurrency Observations

1. Of the 55 current and future programs we assessed, 37 have established an affordability constraint, similar to the implementation rate in our last assessment. The development cost growth for the current programs we assessed with an affordability constraint is 33 percentage points lower than that for programs without a constraint.

2. Of the 43 current programs we assessed, 39 have conducted a "should-cost" analysis resulting in anticipated savings of over $35 billion; approximately $21 billion of these savings have been realized to date.

3. Of the 55 current and future programs we assessed, 43 plan to promote competition at some point during acquisition. Eight of these programs have no plans for competition before or after development start and only half of the future programs we assessed plan to conduct competitive prototyping.

4. Of the 55 current and future programs we assessed, 40 reported software development as a high-risk area. Programs that did not report their software development as high-risk have experienced greater schedule delays. Sixteen of the 43 current programs we assessed plan to concurrently conduct production and software development.

5. Sixteen of the 43 current programs we assessed are in production. Eleven of these programs plan to complete 30 percent or more of their developmental testing concurrent with production. Further, three of these 11 programs plan to place more than 20 percent of its procurement quantities under contract before testing is complete. For the programs we assessed, as concurrency increases, so does total acquisition cost growth.

Additional details about each observation follow.

1. **Of the 55 current and future programs we assessed, 37 have established an affordability constraint, similar to the implementation rate in our last assessment. The development cost growth for programs we assessed with an affordability constraint is 33 percentage points lower than that for programs without a constraint.** In 2010, DOD launched a series of "Better Buying Power" initiatives with the goal of delivering superior capabilities to the warfighter and better value to the taxpayer. One such initiative was the establishment of an affordability analysis that results in cost constraints. This analysis differs from program cost estimates in that the constraint serves as a program requirement to

ensure that the program remains cost-effective.[26] In accordance with DOD Instruction 5000.02, affordability constraints are intended to force prioritization of requirements, enable cost trades, and ensure that unaffordable programs do not enter the acquisition process. When approved affordability constraints cannot be met, a program's technical requirements, schedule, and required quantities must be revisited. Failure to remain within these constraints may result in program termination.

Of the current programs we assessed, 30 of 43 have established an affordability constraint. A similar proportion of programs had implemented affordability constraints in our last assessment. Two programs, the B-2 Defensive Management System Modernization and the Next Generation Operational Control System, responded that they do not currently expect to meet their affordability constraints. Of the remaining 13 programs that have not established an affordability constraint, most began system development before this requirement was established.[27] Similarly, of the 12 future programs we assessed, seven reported that they established an affordability constraint.

The effectiveness of these constraints has yet to be widely tested; however, the programs we assessed that had established an affordability constraint experienced a median of 4 percent growth in development costs from their original baselines. By contrast, the programs we assessed without an affordability constraint experienced a median of 37 percent growth in development costs.[28]

2. **Of the 43 current programs we assessed, 39 have conducted a "should-cost" analysis resulting in anticipated savings of over $35 billion; approximately $21 billion of these savings have been realized to date.** DOD's "Better Buying Power" initiatives also

[26]Affordability goals are established at milestone A, the entry into technology development. After systems engineering trade-offs are completed during the technology development phase, these affordability goals then become affordability caps prior to milestone B, the start of system development, when a match is to be made between requirements and resources. We refer to the goals and caps collectively as affordability constraints.

[27]The Gerald R. Ford Class Nuclear Aircraft Carrier program has a congressionally mandated cost cap, which we do not consider the same as the affordability requirement considered in this analysis. As a result we include this program in the total number of programs without an affordability cap.

[28]For this analysis we took the median cost growth associated with each group of programs to mitigate the effects of programs with significant cost changes.

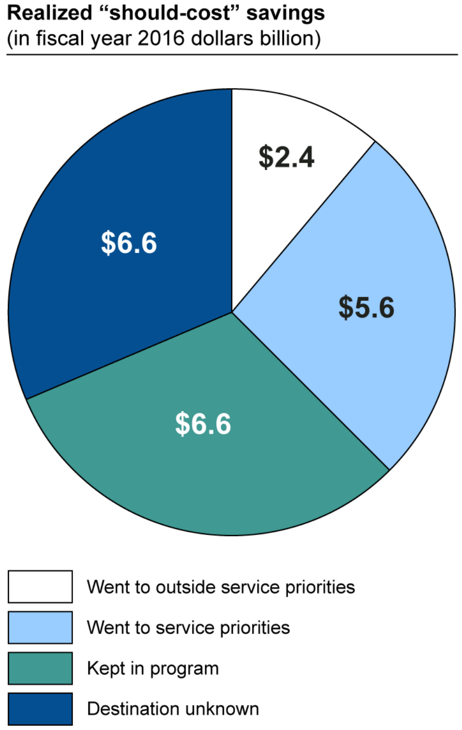
emphasize the importance of driving cost improvements during contract negotiation and program execution to control costs both in the short-term and throughout the product life cycle. In accordance with DOD Instruction 5000.02, each program must conduct a “should-cost” analysis resulting in an estimate to be used as a management tool to control and reduce cost. “Should-cost” analysis can be used to justify each cost under the program’s control with the aim of reducing negotiated prices for contracts and obtaining other efficiencies in program execution to bring costs below those budgeted for the program. Any savings achieved can then be reallocated within the program or for other priorities.

We found that 39 out of 43 current programs conducted a “should-cost” analysis. Three of the four current programs that reported not conducting a “should-cost” analysis are in the process of completing one. Of the 39 programs, 35 identified approximately $35 billion in realized and future savings. Those programs cited several activities as responsible for some or all of their “should-cost” savings, including

- efficiencies realized through contract negotiations (15 programs),
- design trades to balance affordability and capability (12 programs), and
- developmental or operational testing efficiencies (7 programs).

Twenty-six of the 35 programs reported $21.2 billion in realized “should-cost” savings. Of this amount $3.4 billion in savings accrued from savings in development costs, $17.6 billion from procurement costs, and $0.2 billion from other sources. Programs also provided insight as to how their realized savings were allocated. Figure 11 shows the amount of savings reallocated to other purposes.

Figure 11: Priorities for the $21.2 Billion in Total Realized "Should-Cost" Savings



Source: GAO analysis of survey data. | GAO-16-329SP

Of the $21.2 billion in realized "should-cost" savings, $6 billion was kept within the programs to fund other priorities. Programs reported that nearly $286 million of those savings were used to offset budget cuts required by sequestration. Another $5.6 billion of the realized "should-cost" savings went to priorities within the service to which the program belongs and $2.4 billion went to priorities outside of the service. While delivering value to the taxpayer in the acquisition process is one of DOD's stated objectives, programs may not have strong incentives to realize or report "should-cost" savings if those programs perceive them as resulting in the funding of other DOD priorities. Programs we assessed were unable to account for the destination of roughly a third of the savings they reported.

Current programs that we surveyed expect to realize another $13.8 billion in future should cost savings. Of this amount, $8.5 billion in savings is expected to accrue for development and procurement "should-cost" savings and $5.3 billion is expected from other sources. Of the 12 future programs we assessed, 3 reported having conducted a "should-cost" analysis, and identified $9.6 billion in future

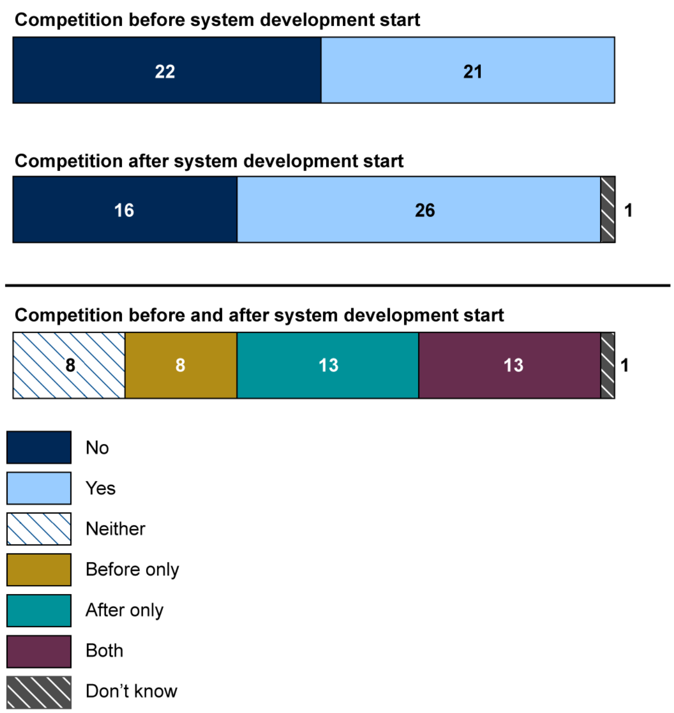
development and procurement savings and an additional $7.9 billion in other savings.

3. **Of the 55 current and future programs we assessed, 43 plan to promote competition at some point during the acquisition cycle. Eight of these programs have no plans for competition before or after development start and only half of the future programs we assessed plan to conduct competitive prototyping.** Competition is a critical tool for achieving the best return on the government's investment. Major defense acquisition programs are generally required to plan for the use of prototypes from two or more contractors before a program starts system development and have acquisition strategies that ensure the option of continued competition throughout the acquisition life cycle.[29] According to DOD, the fostering of competitive environments is a central tenet in acquisition reform and the single best way to motivate contractors to provide the best value.

   Figure 12 shows how current programs plan to promote competition:

[29]Pub. L. No. 111-23, §§ 202, 203, as implemented in DOD Instruction 5000.02. Under certain circumstances this requirement may be waived.

Figure 12: Current Programs' Plans to Promote Competition

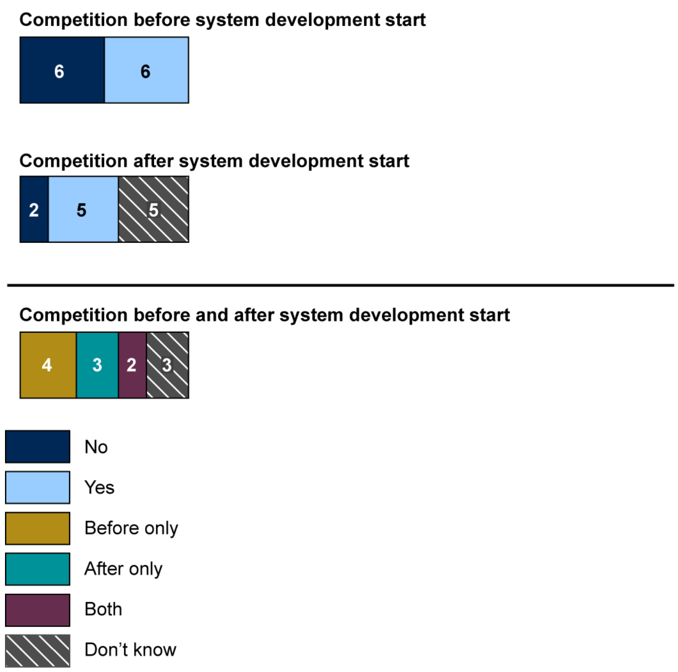


Source: GAO analysis of DOD data. | GAO-16-329SP

Of the 43 current programs we assessed, 21 conducted or planned to conduct competitive prototyping before development start and 26 have acquisition strategies that include some measure to encourage competition after development start, such as funding of next generation prototype systems or subsystems. Thirteen current programs reported pursuing measures to promote competition both before and after the start of system development. These programs experienced less development cost growth than those that promoted competition in only one phase of acquisition. Eight programs reported no plans to pursue competition either before or after beginning system development and one could not describe its current strategy for competition. Six of these are programs new to the portfolio within the last two years.

Figure 13 shows how future programs plan to promote competition:

Figure 13: Future Programs' Plans to Promote Competition



Source: GAO analysis of DOD data. | GAO-16-329SP

Six of 12 future programs reported plans to conduct competitive prototyping before the start of system development; the other six indicated they would not. Our prior work has shown that competitive prototyping can help programs reduce technical risk, refine requirements, and validate designs and cost estimates prior to making major commitments of resources.[30] Programs not taking this step may be missing an opportunity to lower costs and reduce risk. Additionally, five future programs indicated that they would pursue measures to promote competition after the start of system development. Five of the future programs were unable to provide us with information on their plans after development start.

[30]GAO, *National Defense: Department of Defense's Waiver of Competitive Prototyping Requirement for the Navy's Fleet Replenishment Oiler Program*, GAO-15-57R (Washington, D.C.: Oct. 8, 2014).

We asked both current and future programs about specific measures they intend to pursue in order to promote competition after the start of system development. The programs reported most frequently that they have or intend to

- hold periodic system or program reviews to address long-term competitive effects of program decisions,
- use modular, open architectures to enable competition for upgrades; and
- acquire complete technical data packages.

This is significant, as we have previously found that use of these strategies can reduce product development time and life-cycle costs, increase competition and innovation, and enable interoperability between systems.[31]

4. **Of the 55 current and future programs we assessed, 40 reported software development as a high-risk area. Programs that did not report their software development as high-risk have experienced greater schedule delays. Sixteen of the 43 current programs we assessed plan to concurrently conduct production while completing software development.** We found in 2004 that major defense acquisition programs were becoming increasingly reliant on software to achieve their performance characteristics.[32] Software development has similar phases to that of hardware and—in the case of new systems—occurs in parallel with hardware development until software and hardware components are integrated.

   Of the 43 current programs we surveyed, 33 indicated that they had identified software development as a high-risk area. Of the 12 future programs, seven identified their software development as high risk. This is a larger proportion than what we observed in our last assessment, where 25 of 38 current programs identified software development as high-risk. Programs often identified more than one

[31]GAO, *Defense Acquisitions: Review of Private Industry and Department of Defense Open Systems Experiences,* GAO-14-617R (Washington, D.C.: June 26, 2014).

[32]GAO, Defense Acquisitions: Stronger Management Practices Are Needed to Improve DOD's Software-Intensive Weapon Acquisitions, GAO-04-393 (Washington, D.C.: March 1, 2004).

reason for designating software as high risk. The three most common reasons included

- 27 programs that cited the challenge of completing the software development needed to conduct developmental testing;
- 26 programs underestimated the difficultly of their originally planned software effort; and
- 17 programs required hardware design changes, which necessitated additional software development.

A similar proportion of programs in our last assessment identified these issues as motivation for identifying software as a high-risk area, which may indicate that these areas are due additional attention from program managers. Ten programs reported that they had not identified software as a risk, including one program that expects to begin production before completing software development. Those programs experienced, on average, nine additional months of schedule delays compared to programs that had identified software as a high-risk area. In a few cases, those delays are directly attributable to software-development related challenges. The challenges associated with software development have featured in a number of saliently poor acquisition outcomes in DOD, consequently it is encouraging that more programs have begun to identify it as a risk area.

Sixteen of the 43 current programs we assessed plan to begin production prior to completing the software development necessary for integration with system hardware and achieving baseline capabilities, a smaller proportion than our previous assessment. DOD policy allows for some degree of concurrency between initial production and the completion of developmental testing, especially for the completion of software. While some concurrency may be necessary when rapidly fielding urgently needed capabilities, pursuing software development while the system is in production may introduce risks if problems are discovered late in testing. For example, we have reported on the F-35 Joint Strike Fighter program, whose problems necessitated hardware changes to supplement the software or

required the acceptance of software whose reliability falls short of overall system requirements.[33]

5. **Sixteen of the 43 current programs we assessed are in production. Eleven of these programs plan to complete 30 percent or more of their developmental testing concurrent with production. Further, 3 of these 11 programs plan to place 20 percent or more of their procurement quantities under contract before testing is complete. For the programs we assessed, as concurrency increases, so does total acquisition cost growth.** Development testing is intended to demonstrate that a chosen design has the capabilities required and to discover and fix problems before a system enters production. Though DOD policy allows some degree of concurrency between initial production and developmental testing, beginning production before demonstrating that a system will work as intended increases the risk of deficiencies that require substantial design changes and costly modifications to already-constructed systems.

   Eleven of these programs plan to complete a significant portion of their testing—30 percent or more—after they start production. When we examined the relationship between concurrency and total cost growth for programs in production, we found that as concurrency increases, so does the total acquisition cost growth. We also found that programs with higher total costs tend to be more concurrent than programs with lower total costs. A number of relatively expensive and concurrent programs have yet to enter production, exposing them to increased risk of design changes and costly retrofits. Our previous work has found that highly concurrent acquisition strategies can result in poor cost, schedule, and performance outcomes.[34]

   Three of these 11 programs plan to place more than 20 percent of their procurement quantities under contract before testing is complete. For example, the AIM-9X Block II program reported that it had about 33 percent of its total procurement quantity under contract, at a cost of approximately $961 million, before completing development testing.

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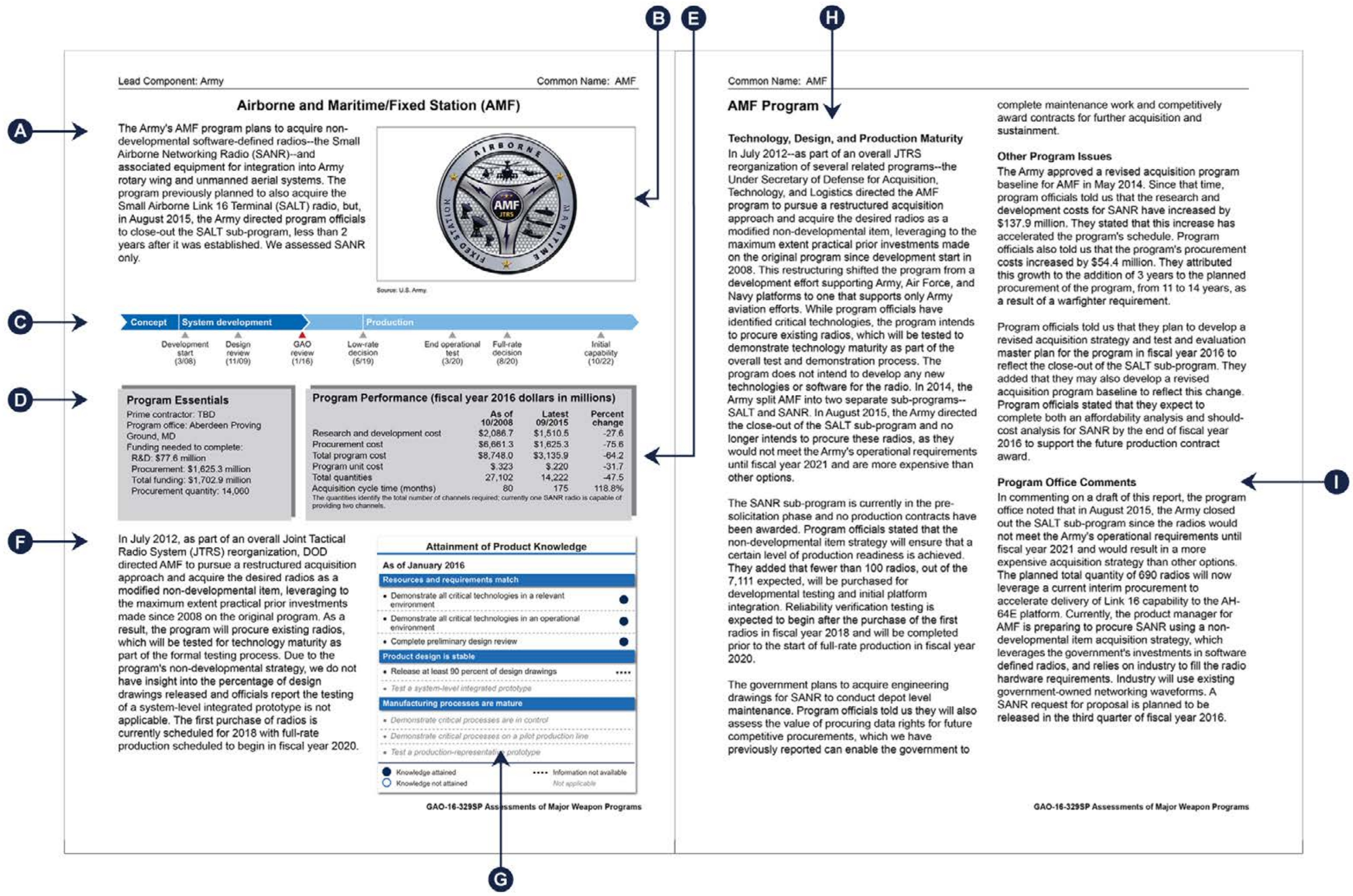
[33]GAO, *F-35 Joint Strike Fighter: Problems Completing Software Testing May Hinder Delivery of Expected Warfighting Capabilities,* GAO-14-322 (Washington, D.C.: Mar. 24, 2014).

[34]GAO, *Ford Class Aircraft Carrier: Poor Outcomes Are the Predictable Consequences of the Prevalent Acquisition Culture*, GAO-16-84T (Washington, D.C.: October 1, 2015).

Assessments of Individual Programs

This section contains assessments of individual weapon programs which are grouped by lead service—Army, Navy and Marine Corps, Air Force, and DOD-led—and include a lead service separator page at the start of each grouping. Each assessment presents data on the extent to which programs are following a knowledge-based acquisition approach to product development and other program information. Each lead service separator page summarizes information about the acquisition phase, current estimated funding needs, cost and schedule growth, and product knowledge attained provided in the assessments that follow. In total, we present information on 55 programs. For 42 programs, we produced two-page assessments discussing the technology, design, and manufacturing knowledge obtained, as well as other program issues. Each two-page assessment also contains a comparison of total acquisition cost from the first full estimate for the program to the current estimate. The first full estimate is generally the cost estimate established at development start; however, for a few programs that did not have such an estimate, we used the estimate at production start instead. For shipbuilding programs, we used their planning estimates if those estimates were available. For programs that began as non–major defense acquisition programs, we used the first full estimate available. Thirty-nine of these 42 two-page assessments are of major defense acquisition programs, most of which are in development or early production, and three assessments are of programs that were projected to become major defense acquisition programs during or soon after our review. See figure 14 for an illustration of the layout of each two-page assessment. In addition, we produced one-page assessments on the current status of 13 programs, which include 12 future major defense acquisition programs and one major defense acquisition program that is well into production.

Figure 14: Illustration of Program Two-Page Assessment



Lead Component: Army   Common Name: AMF

Airborne and Maritime/Fixed Station (AMF)

The Army's AMF program plans to acquire non-developmental software-defined radios--the Small Airborne Networking Radio (SANR)--and associated equipment for integration into Army rotary wing and unmanned aerial systems. The program previously planned to also acquire the Small Airborne Link 16 Terminal (SALT) radio, but, in August 2015, the Army directed program officials to close-out the SALT sub-program, less than 2 years after it was established. We assessed SANR only.

Source: U.S. Army.

Program Essentials

Prime contractor: TBD
Program office: Aberdeen Proving Ground, MD
Funding needed to complete:
R&D: $77.6 million
Procurement: $1,625.3 million
Total funding: $1,702.9 million
Procurement quantity: 14,060

Program Performance (fiscal year 2016 dollars in millions)

	As of 10/2008	Latest 09/2015	Percent change
Research and development cost	$2,086.7	$1,510.5	-27.6
Procurement cost	$6,661.3	$1,625.3	-75.6
Total program cost	$8,748.0	$3,135.9	-64.2
Program unit cost	$.323	$.220	-31.7
Total quantities	27,102	14,222	-47.5
Acquisition cycle time (months)	80	175	118.8%

The quantities identify the total number of channels required; currently one SANR radio is capable of providing two channels.

In July 2012, as part of an overall Joint Tactical Radio System (JTRS) reorganization, DOD directed AMF to pursue a restructured acquisition approach and acquire the desired radios as a modified non-developmental item, leveraging to the maximum extent practical prior investments made since 2008 on the original program. As a result, the program will procure existing radios, which will be tested for technology maturity as part of the formal testing process. Due to the program's non-developmental strategy, we do not have insight into the percentage of design drawings released and officials report the testing of a system-level integrated prototype is not applicable. The first purchase of radios is currently scheduled for 2018 with full-rate production scheduled to begin in fiscal year 2020.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	••••
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained   •••• Information not available
○ Knowledge not attained   *Not applicable*

GAO-16-329SP Assessments of Major Weapon Programs

Common Name: AMF

AMF Program

Technology, Design, and Production Maturity
In July 2012--as part of an overall JTRS reorganization of several related programs--the Under Secretary of Defense for Acquisition, Technology, and Logistics directed the AMF program to pursue a restructured acquisition approach and acquire the desired radios as a modified non-developmental item, leveraging to the maximum extent practical prior investments made on the original program since development start in 2008. This restructuring shifted the program from a development effort supporting Army, Air Force, and Navy platforms to one that supports only Army aviation efforts. While program officials have identified critical technologies, the program intends to procure existing radios, which will be tested to demonstrate technology maturity as part of the overall test and demonstration process. The program does not intend to develop any new technologies or software for the radio. In 2014, the Army split AMF into two separate sub-programs--SALT and SANR. In August 2015, the Army directed the close-out of the SALT sub-program and no longer intends to procure these radios, as they would not meet the Army's operational requirements until fiscal year 2021 and are more expensive than other options.

The SANR sub-program is currently in the pre-solicitation phase and no production contracts have been awarded. Program officials stated that the non-developmental item strategy will ensure that a certain level of production readiness is achieved. They added that fewer than 100 radios, out of the 7,111 expected, will be purchased for developmental testing and initial platform integration. Reliability verification testing is expected to begin after the purchase of the first radios in fiscal year 2018 and will be completed prior to the start of full-rate production in fiscal year 2020.

The government plans to acquire engineering drawings for SANR to conduct depot level maintenance. Program officials told us they will also assess the value of procuring data rights for future competitive procurements, which we have previously reported can enable the government to complete maintenance work and competitively award contracts for further acquisition and sustainment.

Other Program Issues
The Army approved a revised acquisition program baseline for AMF in May 2014. Since that time, program officials told us that the research and development costs for SANR have increased by $137.9 million. They stated that this increase has accelerated the program's schedule. Program officials also told us that the program's procurement costs increased by $54.4 million. They attributed this growth to the addition of 3 years to the planned procurement of the program, from 11 to 14 years, as a result of a warfighter requirement.

Program officials told us that they plan to develop a revised acquisition strategy and test and evaluation master plan for the program in fiscal year 2016 to reflect the close-out of the SALT sub-program. They added that they may also develop a revised acquisition program baseline to reflect this change. Program officials stated that they expect to complete both an affordability analysis and should-cost analysis for SANR by the end of fiscal year 2016 to support the future production contract award.

Program Office Comments
In commenting on a draft of this report, the program office noted that in August 2015, the Army closed out the SALT sub-program since the radios would not meet the Army's operational requirements until fiscal year 2021 and would result in a more expensive acquisition strategy than other options. The planned total quantity of 690 radios will now leverage a current interim procurement to accelerate delivery of Link 16 capability to the AH-64E platform. Currently, the product manager for AMF is preparing to procure SANR using a non-developmental item acquisition strategy, which leverages the government's investments in software defined radios, and relies on industry to fill the radio hardware requirements. Industry will use existing government-owned networking waveforms. A SANR request for proposal is planned to be released in the third quarter of fiscal year 2016.

GAO-16-329SP Assessments of Major Weapon Programs

A Program description

B Illustration or photo of system

C Schedule timeline identifying key dates for the program including the start of development, major design reviews, production decisions, and planned operational capability

D **Program Essentials** Programmatic information including the prime contractor, program office location, and funding needed to complete

E **Program Performance** Cost and schedule baseline estimates and the latest estimate provided as of January 2016

F Brief summary describing the program's implementation of knowledge-based acquisition practices and its current status

G **Attainment of Product Knowledge** Depiction of selected knowledge-based practices and the program's progress in attaining that knowledge

H Assessment of program's technology, design, and production maturity, as well as other program issues

I **Program Office Comments** General comments provided by the cognizant program office

Source: GAO analysis. | GAO-16-329SP

For our two-page assessments, we depict the extent of knowledge gained in a program at the time of our review with a scorecard and narrative summary at the bottom of the first page of each assessment. As illustrated in figure 14 above, the scorecard displays eight key knowledge-

based acquisition practices that should be implemented by certain points in the acquisition process. The more knowledge the program has attained by each of these key points, the more likely the weapon system will be delivered within its estimated cost and schedule. A knowledge deficit means the program is proceeding without sufficient knowledge about its technologies, design, or manufacturing processes, and faces unresolved risks that could lead to cost increases and schedule delays.

For each program, we identify a knowledge-based practice that has been implemented with a closed circle. We identify a knowledge-based practice that has not yet been implemented with an open circle. If the program did not provide us with enough information to make a determination, we show this with a dashed line. A knowledge-based practice that is not applicable to the program is grayed out. A knowledge-based practice may not be applicable to a particular program if the point in the acquisition cycle when the practice should be implemented has not yet been reached, or if the particular practice is not relevant to the program. For programs that have not yet entered system development, we show a projection of knowledge attained for the first three practices. For programs that have entered system development but not yet held a critical design review, we assess actual knowledge attained for these three practices. For programs that have held a critical design review but not yet entered production, we assess knowledge attained for the first five practices. For programs that have entered production, we assess knowledge attained for all eight practices.

We make adjustments to both the key points in the acquisition cycle and the applicable knowledge-based practices for shipbuilding programs. For shipbuilding programs that have not yet awarded a detailed design contract, we show a projection of knowledge attained for the first three practices. For shipbuilding programs that have awarded this contract but not yet started construction, we would assess actual knowledge attained for these three practices. For shipbuilding programs that have started construction, we assess the knowledge attained for the first four practices. We do not assess the remaining four practices for shipbuilding programs, as they are not applicable for these programs. See figure 15 for examples of the knowledge scorecards we use to assess these different types of programs.

Figure 15: Examples of Knowledge Scorecards

Program in production

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	○
• Demonstrate critical processes on a pilot production line	○
• Test a production-representative prototype	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

Shipbuilding program

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• Complete three-dimensional product model	●
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

Source: GAO. | GAO-16-329SP

Statement on Small Business Participation

Pursuant to a mandate in a report for the National Defense Authorization Act for Fiscal Year 2013, we reviewed whether individual subcontracting reports from a program's prime contractor or contractors were accepted on the Electronic Subcontracting Reporting System (eSRS).[35] We reviewed this information for 79 of the major defense acquisition programs in our assessment that reported contract information in their December 2014 Selected Acquisition Report (SAR) submissions. The contract numbers for each program's prime contracts were entered into the eSRS database to determine whether the individual subcontracting reports from the prime contractors had been accepted by the government. The government uses individual subcontracting reports on eSRS as one method of monitoring small business participation, as the report includes goals for small business subcontracting. Not all prime contracts for major defense acquisition programs are required to submit individual subcontracting reports. For example, some contractors report small business participation at a corporate level as opposed to a program level, and this data is not captured in the individual subcontracting reports. Information gathered for this analysis is presented in appendix VI.

[35] H.R. Rep. No. 112-479, at 284 (2012).

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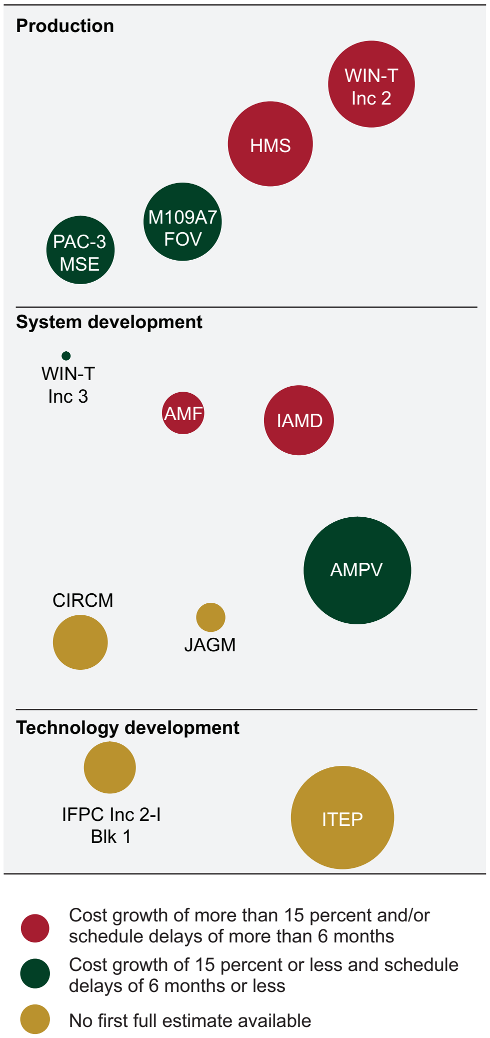
Army Service Summary

We performed in-depth assessments on 10 of the 15 Army major defense acquisition programs in the current portfolio that for the most part are in system development or the early stages of production. We also assessed two Army programs identified as future major defense acquisition progbrams, which are expected to enter system development in the next few years. The Army currently estimates a need of more than $56 billion in funding to complete the acquisition of these programs. The programs in system development or production, where we determined cost and schedule change from first full estimates, have experienced a net cost decrease of almost $17 billion due primarily to quantity decreases on four programs, while average schedule delays of approximately 30 months were also reported. Of these same programs, one, the Armored Multi-Purpose Vehicle, has completed all the activities associated with the applicable knowledge-based best practices we assess.

Acquisition Phase and Size of the 12 Programs Assessed

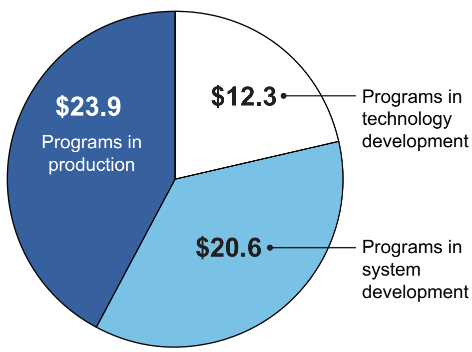


Note: Bubble size is based on each program's currently estimated future funding needed.

Source: GAO analysis of DOD data. | GAO-16-329SP

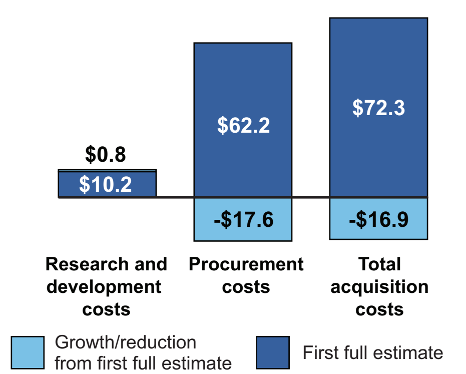
Currently Estimated Acquisition Cost for the 12 Programs Assessed

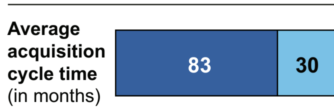
Fiscal year 2016 dollars in billions



Cost and Schedule Growth on 8 Programs in the Current Portfolio

Fiscal year 2016 dollars in billions





Note: In addition to research and development and procurement costs, total acquisition cost includes acquisition related operations and maintenance and system-specific military construction costs.

Summary of Knowledge Attained to Date for Programs Beyond System Development Start

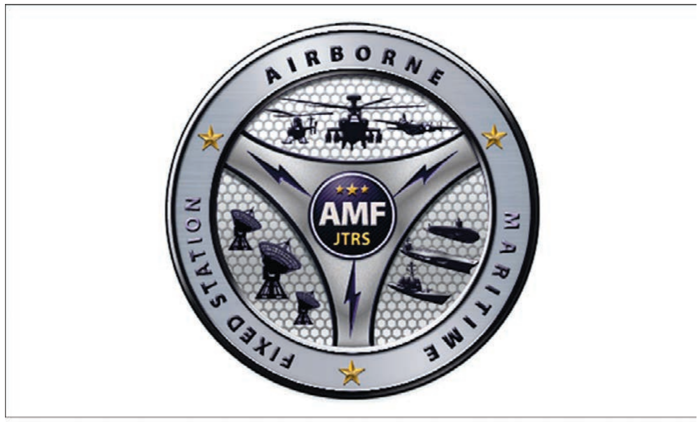
Program common name	Knowledge Point (KP) 1 Resources and requirements match	Knowledge Point 2 Product design is stable	Knowledge Point 3 Manufacturing processes are mature
AMF	●	- - -	KP 3 in future
AMPV	●	KP 2 in future	KP 3 in future
CIRCM	○	KP 2 in future	KP 3 in future
HMS	●	●	○
IAMD	○	●	KP 3 in future
JAGM	○	●	KP 3 in future
M109A7 FOV	●	●	○
PAC-3 MSE	●	●	○
WIN-T Inc 2	●	- - -	●
WIN-T Inc 3	●	○	■

● All applicable knowledge practices were completed
○ One or more applicable knowledge practices were not completed
■ All knowledge practices were not applicable
- - - Information not available for one or more knowledge practice

Army Program Assessments

Airborne and Maritime/Fixed Station (AMF)

The Army's AMF program plans to acquire non-developmental software-defined radios–the Small Airborne Networking Radio (SANR)–and associated equipment for integration into Army rotary wing and unmanned aerial systems. The program previously planned to also acquire the Small Airborne Link 16 Terminal (SALT) radio, but, in August 2015, the Army directed program officials to close-out the SALT sub-program, less than 2 years after it was established. We assessed SANR only.



Source: U.S. Army.

Concept | System development | Production

- Development start (3/08)
- Design review (11/09)
- GAO review (1/16)
- Low-rate decision (5/19)
- End operational test (3/20)
- Full-rate decision (8/20)
- Initial capability (10/22)

Program Essentials

Prime contractor: TBD
Program office: Aberdeen Proving Ground, MD
Funding needed to complete:
R&D: $77.6 million
Procurement: $1,625.3 million
Total funding: $1,702.9 million
Procurement quantity: 14,060

Program Performance (fiscal year 2016 dollars in millions)

	As of 10/2008	Latest 09/2015	Percent change
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Procurement cost	$6,661.3	$1,625.3	-75.6%
Total program cost	$8,748.0	$3,135.9	-64.2%
Program unit cost	$0.323	$0.220	-31.7%
Total quantities	27,102	14,222	-47.5%
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Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	Knowledge attained
• Demonstrate all critical technologies in an operational environment	Knowledge attained
• Complete preliminary design review	Knowledge attained
Product design is stable	
• Release at least 90 percent of design drawings	Information not available
• *Test a system-level integrated prototype*	*Not applicable*
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	*Not applicable*
• *Demonstrate critical processes on a pilot production line*	*Not applicable*
• *Test a production-representative prototype*	*Not applicable*

● Knowledge attained ○ Knowledge not attained ▪▪▪▪ Information not available *Not applicable*

AMF Program

Technology, Design, and Production Maturity

In July 2012–as part of an overall JTRS reorganization of several related programs–the Under Secretary of Defense for Acquisition, Technology, and Logistics directed the AMF program to pursue a restructured acquisition approach and acquire the desired radios as a modified non-developmental item, leveraging to the maximum extent practical prior investments made on the original program since development start in 2008. This restructuring shifted the program from a development effort supporting Army, Air Force, and Navy platforms to one that supports only Army aviation efforts. While program officials have identified critical technologies, the program intends to procure existing radios, which will be tested to demonstrate technology maturity as part of the overall test and demonstration process. The program does not intend to develop any new technologies or software for the radio. In 2014, the Army split AMF into two separate sub-programs–SALT and SANR. In August 2015, the Army directed the close-out of the SALT sub-program and no longer intends to procure these radios, as they would not meet the Army's operational requirements until fiscal year 2021 and are more expensive than other options.

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Other Program Issues

The Army approved a revised acquisition program baseline for AMF in May 2014. Since that time, program officials told us that the research and development costs for SANR have increased by $137.9 million. They stated that this increase has accelerated the program's schedule. Program officials also told us that the program's procurement costs increased by $54.4 million. They attributed this growth to the addition of 3 years to the planned procurement of the program, from 11 to 14 years, as a result of a warfighter requirement.

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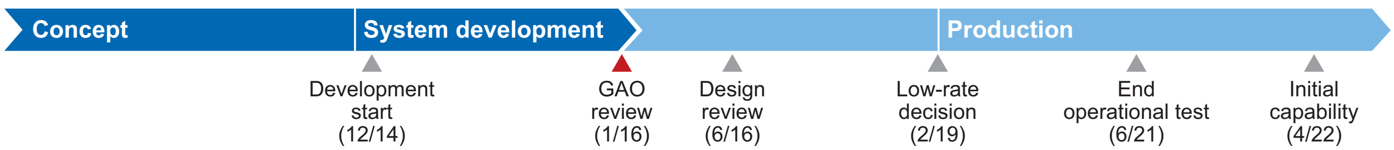
Program Office Comments

In commenting on a draft of this report, the program office noted that in August 2015, the Army closed out the SALT sub-program since the radios would not meet the Army's operational requirements until fiscal year 2021 and would result in a more expensive acquisition strategy than other options. The planned total quantity of 690 radios will now leverage a current interim procurement to accelerate delivery of Link 16 capability to the AH-64E platform. Currently, the product manager for AMF is preparing to procure SANR using a non-developmental item acquisition strategy, which leverages the government's investments in software defined radios, and relies on industry to fill the radio hardware requirements. Industry will use existing government-owned networking waveforms. A SANR request for proposal is planned to be released in the third quarter of fiscal year 2016.

Armored Multi-Purpose Vehicle (AMPV)

The Army's Armored Multi-Purpose Vehicle (AMPV) is the replacement to the M113 family of vehicles at the Brigade level and below. The AMPV will replace the M113 in five mission roles: general purpose, medical evacuation, medical treatment, mortar carrier, and mission command. The Army determined that development of the AMPV is necessary due to mobility, survivability, and force protection deficiencies identified with the M113, as well as space, weight, power, and cooling limitations that prevent the incorporation of future technologies.

Source: BAE Systems.



Program Essentials

Prime contractor: BAE Systems
Program office: Warren, MI
Funding needed to complete:
R&D: $872.3 million
Procurement: $9,886.8 million
Total funding: $10,759.1 million
Procurement quantity: 3,077

Program Performance (fiscal year 2016 dollars in millions)

	As of 05/2015	Latest 07/2015	Percent change
Research and development cost	$1,004.0	$1,031.2	2.7%
Procurement cost	$9,891.9	$9,887.2	0.0%
Total program cost	$10,895.9	$10,918.4	0.2%
Program unit cost	$3.711	$3.719	0.2%
Total quantities	2,936	2,936	0.0%
Acquisition cycle time (months)	87	87	0.0%

The AMPV program entered system development in December 2014 with its critical technologies fully mature. The program held its preliminary design review in June 2015, 6 months after development start. The AMPV program does not intend to develop new technologies; instead, it plans to use readily available components and existing technologies from legacy systems. Although the program did not conduct competitive prototyping prior to system development, the program plans to employ a number of practices prior to its critical design review to increase confidence in the AMPV design and to preserve the possibility of competition in later phases of the program.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• *Release at least 90 percent of design drawings*	
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained ▪▪▪▪ Information not available
○ Knowledge not attained *Not applicable*

AMPV Program

Technology Maturity

The AMPV program entered system development in December 2014 with its critical technologies fully mature as determined by an independent review team. According to program officials, integration risks are low to moderate. According to the results of the program's preliminary design review, software continues to be a risk for the program. Software development for the AMPV program is expected to consist of 80 percent reuse of existing software and 20 percent new development. The AMPV program plans to reuse software under development for an upgrade to another system and previously developed software from a canceled program. The AMPV software schedule is dependent on the software upgrade being developed for this other system. Any significant delay with this software could affect the AMPV software delivery schedule and delivery of development vehicles.

Design and Production Maturity

According to program officials, a majority of the AMPV design is derived from legacy systems. The program held a preliminary design review in June 2015, 6 months after development start, which resulted in 43 action items. As of October 2015, one action item remains open. According to a Defense Contract Management Agency report, the program's prime contractor, BAE Systems, entered into the preliminary design review while sub-systems were undergoing redesign. However, program officials note that, in their experience, it is not uncommon to refine sub-system design between the preliminary and critical design reviews, as the detailed design effort includes sub-system design trades to ensure requirements are met. The major sub-systems BAE redesigned include the hull, radiator, battery, and components of the vehicle propulsion system. According to officials, these modifications will provide increased soldier force protection, power, reliability, and commonality and will have minimal impact to prototype delivery schedule. The program plans to use other knowledge-based practices, such as identifying critical manufacturing processes, prior to critical design review to increase confidence in the stability of the AMPV design.

The Deputy Assistant Secretary of Defense, Systems Engineering identified the availability of production tooling as a high risk area. It determined that BAE will require additional tooling mechanisms before it can begin producing engineering and manufacturing development prototype vehicles in June 2016. The program expects to demonstrate critical manufacturing processes on a pilot production line before the start of production, but the production tooling risk might impact the program's ability to satisfy this best practice if the required tooling is unavailable. Production schedule delays and cost growth could occur if the required tooling is unavailable by the start of production.

Other Program Issues

While the program did not conduct competitive prototyping prior to the start of system development, the program plans to pursue actions to maintain the possibility of competition at the prime contractor level before the completion of production. Specifically, the program plans to acquire complete technical data packages and may use modular, open architectures to enable competition for upgrades. Open systems architecture allows the product to be refreshed with new, improved components made by a variety of suppliers.

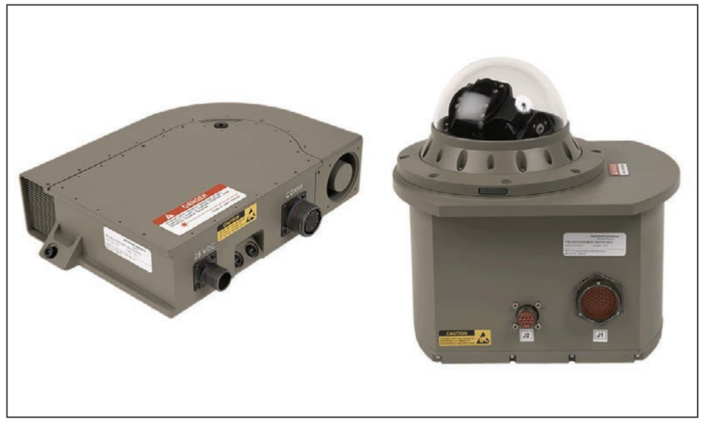
Program Office Comments

In addition to providing technical comments, the program office noted that the risk associated with the software has been downgraded as the software was delivered on schedule with the required functionality. The program is still reliant on limited functionality from the software scheduled to be released late in 2015. This release is currently on schedule, and upon receipt AMPV will no longer be dependent on other systems' software development. The identified production tooling risk has been downgraded since preliminary design review. The remaining concern is final development of assembly fixtures that may cause a maximum of a 30-day schedule slip.

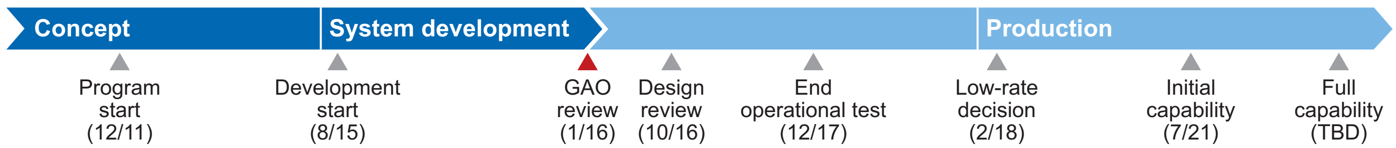
Six months after the scheduled critical design review, BAE Systems will begin the delivery of 29 system-level prototypes for testing. Testing will consist of contractor developmental testing and logistics activities along with a government production prove-out test, live fire test and evaluation, and a limited user test.

Common Infrared Countermeasure (CIRCM)

The Army's CIRCM is the next generation of Advanced Threat Infrared Countermeasures (ATIRCM) designed to defend aircraft from infrared-guided missiles. The program is developing a laser-based system for use with a missile warning system and countermeasure dispenser that deploys expendables, such as flares and chaff. CIRCM will be installed on rotary-wing, tilt-rotor, and small fixed-wing aircraft across DOD. CIRCM was originally started as a subprogram under the ATIRCM/Common Missile Warning System.



Source: Northrop Grumman.



Program Essentials

Prime contractor: Northrop Grumman
Program office: Huntsville, Alabama 35806
Funding needed to complete:
- R&D: $452.7 million
- Procurement: $1,804.6 million
- Total funding: $2,700.7 million
- Procurement quantity: 1,076

Program Performance (fiscal year 2016 dollars in millions)

	As of	Latest 11/2015	Percent change
Research and development cost	N/A	$764.4	N/A
Procurement cost	N/A	$1,804.6	N/A
Total program cost	N/A	$3,012.3	N/A
Program unit cost	N/A	$2.680	N/A
Total quantities	N/A	1,124	N/A
Acquisition cycle time (months)	N/A	115	N/A

The CIRCM program entered system development in August 2015 with its critical technologies approaching maturity based on the results of a technology readiness assessment conducted in December 2014. Independent government testing of system performance validated the previous vendor testing, methodologies, and results. The review team was not able to determine that any of the critical technologies had achieved full maturity as testing of the CIRCM prototypes in an operational environment was not performed. The program limited competition to the two existing contractors from the technology development phase. The Army also plans to purchase 1,076 CIRCM kits for installation on aircraft.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• *Release at least 90 percent of design drawings*	
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
.... Information not available
Not applicable

CIRCM Program

Technology Maturity

The CIRCM program entered system development in August 2015 with its critical technologies approaching full maturity. An independent review team conducted an assessment of the program's nine critical technologies–including the gimbal assembly, camera assembly, the quantum cascade laser, and others–and determined that all technologies were nearing maturity. The key risks going into the technology development phase were CIRCM weight, probability of countermeasure, and reliability. According to the acquisition strategy, key risks to meet CIRCM requirements have been significantly reduced in the technology development phase. A combination of contractor and government testing under realistic flight conditions has allowed the vendors to identify weaknesses and address them with design updates. Government test results indicate that weight and probability of countermeasure have met exit criteria and/or system requirements, and reliability is on a path to meet or exceed exit criteria and/or the system requirements.

Other Program Issues

Pursuant to a recommendation by the Office of the Secretary of Defense, the program limited competition to the two existing contractors from the technology development phase to avoid duplication of cost and development efforts, and because market research indicated that only the current vendors were interested in the development effort. The contract type for system development was changed to also include fixed-price incentive, cost-plus-fixed-fee, and firm-fixed-price terms.

The Undersecretary of Defense for Acquisition, Technology, and Logistics approved CIRCM's entry into the engineering and manufacturing development phase on August 25, 2015. The Army was authorized to proceed with the award of the development contract, with two low-rate initial production options for up to 30 modification kits–which include the hardware, wiring harness, cables necessary to install CIRCM on each aircraft but not the system itself–and 45 hardware kits that include the CIRCM systems, 37 for the Army and up to 8 for the Navy. The Army plans to purchase 1,076 CIRCM systems for installation on aircraft. It will also procure 3,373 modification kits. The installation configuration of CIRCM differs from platform to platform. CIRCM is not intended to be installed on every aircraft but instead will be installed on select aircraft based on the mission and environment. The Undersecretary also directed the Army to request funding consistent with what is required by the independent cost estimate.

The Army awarded its engineering and manufacturing development contract to Northrop Grumman on August 28, 2015. However, the British Aerospace Electronics Systems filed a bid protest on September 8, which resulted in a stop work order on September 9. The bid protest was resolved on November 25 when the protester withdrew its protest and work was resumed on November 30, 2015.

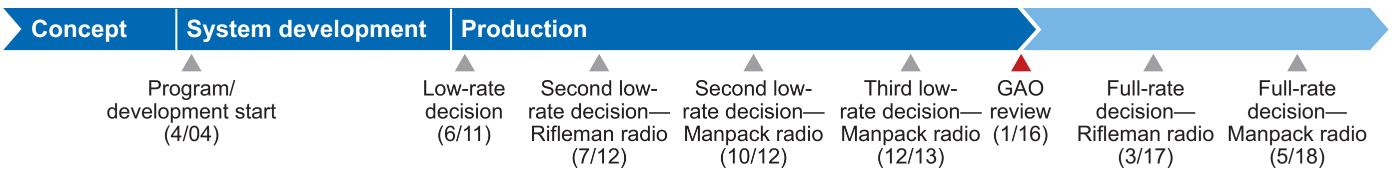
Program Office Comments

In commenting on a draft of this assessment, the program office stated that the bid protest had no major adverse effects to the CIRCM program's cost or performance. However, the protest impacted program schedule, resulting in delayed fielding to the combat aviation brigades. According to program officials, until CIRCM is fully fielded, upgrades to the ATIRCM and current Army Missile Warning System will continue to provide the appropriate coverage to Army aircrews. The program office also provided technical comments, which were incorporated where appropriate.

Handheld, Manpack, and Small Form Fit Radios (HMS)

DOD's Joint Tactical Radio System (JTRS) program, now restructured, was developing software-defined radios to interoperate with existing radios and increase communications and networking capabilities. The Army's HMS program carries on efforts to develop two radios the Rifleman radio and the Manpack radio. A subset of the Manpack radios are designed to operate with the Mobile User Objective System (MUOS), a Navy satellite communication system expected to serve a worldwide, multiservice population of mobile and fixed-site terminal users.

Source: © 2012 General Dynamics C4S.



Program Essentials

Prime contractor: General Dynamics C4 Systems, Inc.
Program office: Aberdeen Proving Ground, MD
Funding needed to complete:
- R&D: $136.0 million
- Procurement: $6,726.4 million
- Total funding: $6,862.5 million
- Procurement quantity: 243,660

Program Performance (fiscal year 2016 dollars in millions)

	As of 05/2004	Latest 12/2014	Percent change
Research and development cost	$5,84.4	$1,395.2	138.8%
Procurement cost	$10,184.7	$7,734.5	-24.1%
Total program cost	$10,769.1	$9,129.8	-15.2%
Program unit cost	$0.033	$0.034	2.7%
Total quantities	328,674	271,202	-17.5%
Acquisition cycle time (months)	85	124	45.9%

Since our last assessment, the HMS program–formerly JTRS HMS–has demonstrated all its critical technologies as mature through testing. However, testing to verify the resolution of issues with the reliability of Manpack and suitability of both radios remains to be completed. According to officials, the HMS program will conduct manufacturing readiness assessments for both the Rifleman and Manpack radios as part of the system's separate full-rate production decisions scheduled in 2017 and 2018, respectively. Testing associated with the use of the Navy's MUOS waveform in some of the radios is significantly delayed. Additionally, HMS program officials stated that changes to these radios necessary for implementation of MUOS required the program to extend the software development effort.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	●
• Demonstrate critical processes on a pilot production line	○
• Test a production-representative prototype	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

HMS Program

Technology and Design Maturity

As of July 2015, more than 10 years after the start of development, the HMS program has demonstrated all of its critical technologies as mature in an operational environment. Testing efforts specific to the critical technologies were completed in May 2015, and subsequent testing efforts are devoted to systemic testing of the two radios. The program office also reports a stable design, with some additional drawings to support redesign work in response to past testing issues. In fiscal year 2014, developmental testing identified concerns with the Manpack radios reliability and operational testing identified suitability concerns due to the weight of the unit. Operational testing also identified suitability problems with the Rifleman radio due to overheating and rapid battery depletion. Program officials stated that redesign efforts performed by the contractor have resolved these problems. However, additional operational testing may be necessary to ensure that all reliability and suitability issues with the two radios have been addressed.

Production Maturity

According to program officials, the HMS program conducted manufacturing readiness assessments for the Rifleman radios, and the evaluation of these results will be completed in advance of its full-rate production decision, scheduled for March 2017. They also stated that the HMS program will conduct manufacturing readiness assessments for the Manpack radios vendors as part of its separate full-rate production decision, scheduled for May 2018. However, the Manpack assessments have not yet been conducted. The program office has identified and collected specification data on the program's critical manufacturing processes.

Other Program Issues

At present, use of the MUOS waveform which some Manpack radios will rely on is largely unavailable to the warfighter because of delays with integrating the waveform, radios, and ground system. Although MUOS was not identified as a critical technology, without this waveform, affected Manpack radios are only able to communicate through legacy communications capabilities. According to program officials, the development work necessary to resolve reliability problems with the MUOS waveform has been completed, and the Navy completed the first phase of operational testing of the MUOS satellite communication system in November 2015, a delay of 17 months. Operational testing of the MUOS waveform is expected to be fully complete by June 2016. The Army plans to leverage this operational testing to inform future fielding decisions. According to program officials, changes to the Manpack radios necessary for implementation of MUOS required the program to extend software development. Additional software development to add new capabilities associated with MUOS is now expected to continue through April 2016.

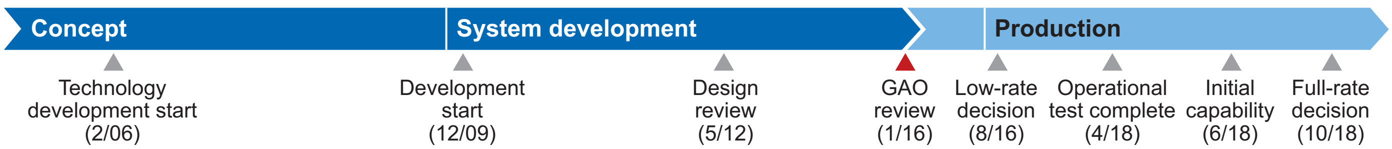
Program Office Comments

In commenting on a draft of this assessment, program officials stated that based on operator feedback during Manpack radio operational testing, the program office developed an improved backpack which provides adequate heat dissipation and weight dispersion. The program plans to deliver 2,500 of these backpacks in 2016. The program office communicated and coordinated with industry to synchronize HMS program and industry partner capabilities for a full and open competition. Currently in source selection, contract award is expected in May 2016. The full-rate production Manpack radio threshold weight is 3.5 pounds lighter than the low-rate production radios, and will meet the 8 hour mission requirement using a single battery.

Integrated Air and Missile Defense (IAMD)

The Army's Integrated Air and Missile Defense (IAMD) program is being developed to network sensors, weapons, and a common battle command system across an integrated fire control network to support the engagement of air and missile threats. The IAMD battle command system will provide a capability to control and manage IAMD sensors and weapons, such as the Sentinel radar and Patriot launcher and radar, through an interface module that supplies battle management data and enables networked operations.

Source: Northrop Grumman.



Program Essentials

Prime contractor: Northrop Grumman Space & Mission Systems Corp, Raytheon Integrated Defense Systems
Program office: Redstone Arsenal, AL
Funding needed to complete:
- R&D: $875.2 million
- Procurement: $3,770.3 million
- Total funding: $4,645.5 million
- Procurement quantity: 427

Program Performance (fiscal year 2016 dollars in millions)

	As of 12/2009	Latest 12/2014	Percent change
Research and development cost	$1,711.4	$2,600.9	52.0%
Procurement cost	$3,683.6	$3,770.3	2.4%
Total program cost	$5,395.0	$6,371.1	18.1%
Program unit cost	$18.226	$14.382	-21.1%
Total quantities	296	443	49.7%
Acquisition cycle time (months)	80	102	27.5%

IAMD technologies are approaching full maturity and at least 90 percent of the design drawings have been released. The program has encountered software integration and synchronization challenges, but according to program officials, a software development re-plan approved in early 2013 established incremental deliveries to mitigate these challenges. To further reduce risk, the program rebaselined its schedule and deferred initial operational capability by 2 years. IAMD has begun developmental flight tests and completed the first two test flights. Both flight tests were assessed as having met all test objectives, including communicating within the system, tracking, and intercepting the target. Two additional flight tests are planned before the low-rate initial production decision scheduled in August 2016.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

IAMD Program

Technology Maturity

IAMD's four critical technologies–integrated battle command, integrated defense design, integrated fire control network, and distributed track management–are not expected to be fully mature until the program's low-rate initial production decision in August 2016. The program entered system development in 2009 with these technologies assessed as approaching full maturity based on a notional design.

Design Maturity

According to program officials, IAMD is dependent on other acquisition programs such as Patriot and radar programs to deliver components and conduct testing. As system integrator, the program must coordinate other programs' priorities and changes to ensure synchronization. Although the program reports that all of the expected design drawings have been released, it has encountered challenges integrating and synchronizing new software from the contractor with the other acquisition programs IAMD relies on for its functionality. To reduce integration risks, the program approved a software development re-plan in April 2013, which established an incremental delivery schedule and updated software size estimates. According to program officials, IAMD is receiving software deliveries to support the test program and will receive updated versions of the software throughout developmental testing. In May 2015, the Army conducted the first of four planned flight tests. The overall test objective was to demonstrate the capability of the system to receive information from sensors and communicate information to the launcher and missile to attack a target in flight. According to officials, the first flight test completely met 7 of 11 primary objectives and substantially met the other 4. The test also included two secondary objectives that have relevance for later flights; IAMD completely met one and partially met the second. A second flight test, conducted in November, also intercepted the target and demonstrated the system’s ability to identify, track, engage, and kill targets using an interceptor from one system and remote sensors from another system under control of the IAMD battle command system. A limited user test is scheduled for completion before the low-rate initial production decision in August 2016.

Program Office Comments

The program office was provided a draft of this assessment and did not have any comments.

Joint Air-to-Ground Missile (JAGM)

The Joint Air-to-Ground Missile is an Army-led program with joint requirements from the Navy and Marine Corps. The missile is designed to be air-launched from helicopters and unmanned aircraft systems to target tanks; light armored vehicles; missile launchers; command, control and communications vehicles; bunkers; and buildings. It is intended to provide line-of-sight, fire-and-forget, and precision attack capabilities in day, night, and adverse weather conditions. JAGM will replace all HELLFIRE missile variants.

Source: U.S. Army.

Concept | System development | Production

- Development start (7/15)
- Design review (1/16)
- GAO review (1/16)
- Start operational test (6/17)
- Low-rate decision (9/17)
- Initial operational capability (9/18)
- Full-rate decision (6/19)

Program Essentials

Prime contractor: Lockheed Martin
Program office: Redstone Arsenal, AL

Funding needed FY 2016 to FY 2020
- R&D: $200.9 million
- Procurement: $562.4 million
- Total funding: $763 million
- Procurement quantity: 1,599

Program Performance (fiscal year 2016 dollars in millions)

	As of	Latest 06/2015	Percent change
Research and development cost	N/A	$994.1	N/A
Procurement cost	N/A	$562.4	N/A
Total program cost	N/A	$1,556.6	N/A
Program unit cost	N/A	N/A	N/A
Total quantities	N/A	1,599	N/A
Acquisition cycle time (months)	N/A	38	N/A

The latest cost and quantity data reflect only the funding and quantities planned for fiscal years 2008 through 2020 and not the cost and quantities to complete.

JAGM entered system development in July 2015, after extending its technology development by more than two years, and had not yet demonstrated its critical technologies in a realistic environment. A preliminary design review of the fully integrated missile was not conducted prior to development start. Instead, the program relied on component level reviews and reviews conducted for a previous design. JAGM's technologies and design are expected to be mature by its scheduled critical design review planned in January 2016. The program plans to manufacture JAGM on an existing production line used for HELLFIRE that will require minor modifications to accommodate the longer JAGM. The program has not yet assessed production maturity, but plans to demonstrate the new processes for JAGM on the modified production line and assess manufacturing processes before entering production.

Attainment of Product Knowledge

Projected as of January 2016

Resources and requirements match	
Demonstrate all critical technologies in a relevant environment	●
Demonstrate all critical technologies in an operational environment	●
Complete preliminary design review	○
Product design is stable	
Release at least 90 percent of design drawings	●
Test a system-level integrated prototype	●
Manufacturing processes are mature	
Demonstrate critical processes are in control	
Demonstrate critical processes on a pilot production line	
Test a production-representative prototype	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

JAGM Program

Technology Maturity

JAGM has three critical technologies–the guidance seeker assembly/sensor platform, sensor software, and mission software. The sensor software is fully mature while the mission software and guidance seeker assembly/sensor platform are projected to reach full maturity by the critical design review. In 2012, JAGM extended its technology development period by more than two years and determined that requirements could be met with existing technologies–a HELLFIRE motor, warhead, and electronics–coupled with a newly developed guidance system. In July 2015, the Army awarded a system development contract for the guidance system to Lockheed Martin, which is also expected to manufacture the fully integrated missile. Program officials identified the JAGM software development effort as a risk area. The program uses nine different metrics measuring software size, requirements, testing, and defects to assess software development progress and maturity with all of them currently meeting expected values.

Design Maturity

A system-level preliminary design review was completed in June 2010 on a JAGM design developed prior to the program's restructuring in March 2012. Design changes were made to the missile as part of this effort, but additional reviews were completed only for the guidance subsystem and not the re-designed, fully integrated missile. DOD waived the requirement to conduct a system-level preliminary review of the new design before the start of system development based on these prior reviews and JAGM's technology maturity. Program officials report that the current design effort consists of maturing the 180 design drawings for the guidance subsystem, 177 of which are complete. The remaining drawings relate to the subsystem's integration with the missile. According to program officials, these drawings are projected to be prepared by the program's critical design review, currently scheduled for January 2016.

Production Maturity

JAGM will be manufactured at the same facility as HELLFIRE–the missile JAGM will replace. Only minimal changes are expected to the assembly line to accommodate the longer JAGM. For example, new holding fixtures, test sets, and paint equipment need to be updated to accommodate the longer JAGM. Production maturity has not yet been assessed, but before JAGM enters production the program office plans to demonstrate critical processes on the modified assembly line in the last quarter of fiscal year 2017. In addition to demonstrating and qualifying the line before production, the program also plans to assess the extent to which critical manufacturing processes are under statistical control and reliably yield a product that meets design specifications.

Other Program Issues

The Army is tracking several risks that could affect cost and schedule. One risk relates to the in-flight reliability requirement. According to program officials, there must be no more than two failures out of the 48 JAGM engineering and manufacturing test flights. If more than two failures occur, the Army estimates that required funding could increase by as much as 10 percent, and the schedule would be delayed to identify the root cause of the failures and correct them. The reliability requirement, however, is being reevaluated and may be descoped pending Joint Requirements Oversight Council approval. The program is also tracking risks related to schedule, design maturity, and production. These risks, according to the program, would present minimal or no impact on cost, schedule, or performance.

Program Office Comments

In commenting on a draft of this assessment, the program office indicated that the JAGM incremental strategy leveraged the results from the competitive prototyping technology development phase to develop a multi-mode seeker to integrate with the HELLFIRE backend. The approach, according to the program, was an effort to promote fair competition. Additionally, not testing technologies in a realistic environment prior to development start was the result of budget constraints on the program.

M109A7 Family of Vehicles (M109A7 FOV)

The Army's M109A7 FOV system consists of two individual platforms, a self-propelled howitzer (SPH) and a tracked ammunition carrier that provides operational support. The SPH is a tracked, aluminum armored vehicle with a 155 millimeter cannon. The M109A7 FOV is expected to provide improved sustainability over the current howitzer fleet through the incorporation of a newly designed hull; modified M2 Bradley infantry fighting vehicle power train, suspension system, and track; and a modernized electrical system.

Source: U.S. Army.

Concept | System development | Production

- Development start (6/07)
- Design review (12/08)
- Low-rate decision (10/13)
- GAO review (1/16)
- Start operational test (10/16)
- Full-rate decision (3/17)
- Initial capability (6/17)

Program Essentials

Prime contractor: BAE Systems Land & Armament L.P.
Program office: Warren, MI
Funding needed to complete:
R&D: $194.4 million
Procurement: $5,432.6 million
Total funding: $5,627.0 million
Procurement quantity: 521

Program Performance (fiscal year 2016 dollars in millions)

	As of 02/2012	Latest 06/2015	Percent change
Research and development cost	$1,081.5	$1,134.9	4.9%
Procurement cost	$6,094.1	$6,066.0	-0.5%
Total program cost	$7,175.6	$7,200.9	0.4%
Program unit cost	$12.329	$12.905	4.7%
Total quantities	582	558	-4.1%
Acquisition cycle time (months)	118	120	1.7%

The M109A7 FOV program entered low-rate production in October 2013 with its two critical technologies mature and design stable. However, the program is implementing a number of design changes to the vehicle's transmission, fire control system, and information assurance architecture that will result in retrofits to numerous vehicles, cost increases, and program delays. As of August 2015, the program office indicated that a number of manufacturing processes and systems are not fully mature and the capability to produce the vehicles has not yet been demonstrated. The program is also completing developmental testing concurrently with production. This concurrency between testing and production could leave it at risk for additional design changes and costly retrofits to delivered vehicles if further deficiencies are found during testing.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	○
• Demonstrate critical processes on a pilot production line	○
• Test a production-representative prototype	●

● Knowledge attained
○ Knowledge not attained
.... Information not available
Not applicable

M109A7 FOV Program

Technology and Design Maturity

The M109A7 FOV program's two critical technologies–power pack integration and the ceramic bearing of the generator assembly–have been assessed as fully mature. These technologies are identified as critical based on concerns about their performance at high temperatures. While neither technology is new, failure of either would represent a major program risk.

According to program officials, the design is currently stable with all of the expected drawings released and a system-level integrated prototype demonstrated. The program is, however, completing a number of design changes that will result in at least some retrofits to all 67 low-rate production vehicles. Program officials indicated that the current M109A7 transmission will be replaced at full-rate production by a more efficient transmission, resulting in retrofits to all 67 low-rate production vehicles. They also stated that the M109A7's current steel cannon tube will also be replaced with a chrome plated design to meet its design life, which will require additional retrofitting for those vehicles produced prior to July 2015. Furthermore, the current M109A7 vehicle architecture for information assurance requires soldiers to remove, store, and secure modular components, thus increasing operational burden. A proposed vehicle architecture re-design reduces the burden to soldiers having to complete excessive procedures but will also require retrofits. Finally, a key component in the M109A7's fire control system remains a risk as the gun can drift off target.

Production Maturity

The program started production in October 2013, and the first vehicle was delivered in March 2015. To assess its production maturity, the program uses metrics related to labor utilization, quality defects, and manufacturing readiness levels. Currently, the program's manufacturing readiness levels for process capability and control indicate that its critical production processes are not all in statistical control. Our best practices work has shown that if a program's critical manufacturing processes are not demonstrated and in control before production begins, it is at risk of increased cost and schedule. According to program officials, early production results showed that the contractor underestimated the number of labor hours required for manufacturing, which may contribute to an estimated $13 million in increased costs for the first production lot.

Other Program Issues

The program's current schedule has a limited amount of time and flexibility to correct deficiencies identified during developmental testing. System-level developmental testing is expected to complete in October 2016, approximately 3 years after production start. As a result, the Army will contract for the production of more than 65 M109A7 FOV systems before completing development testing. The program's estimated cost to cover the retrofits related to problems already discovered in testing is nearly $20 million. This could increase if additional deficiencies are found during the testing that require design changes or retrofits.

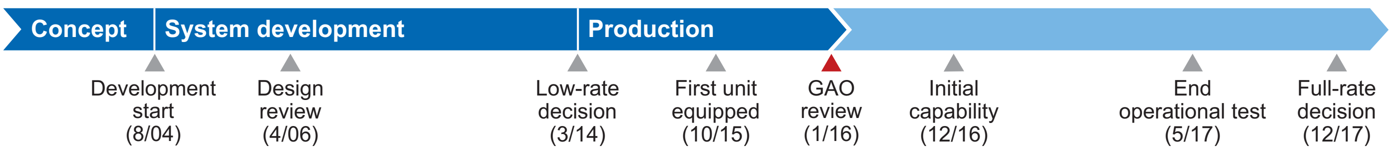
Program Office Comments

In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE)

The Army's PAC-3 MSE is a surface-to-air missile designed to defeat tactical ballistic missiles and other aerial threats. Originally a subprogram under the PATRIOT/Medium Extended Air Defense System Combined Aggregate Program (PATRIOT/MEADS CAP), PAC-3 MSE became a separate program after the cancellation of PATRIOT/MEADS CAP in 2013. As part of the PATRIOT system, which includes radars and launchers, PAC-3 MSE improves upon earlier PAC-3 variants and is expected to provide a more lethal interceptor with increased battlespace performance.

Source: U.S. Army.



Program Essentials

Prime contractor: Lockheed Martin
Program office: Redstone Arsenal, AL
Funding needed to complete:
- R&D: $2.3 million
- Procurement: $4,227.5 million
- Total funding: $4,239.1 million
- Procurement quantity: 893

Program Performance (fiscal year 2016 dollars in millions)

	As of 08/2004	Latest 07/2015	Percent change
Research and development cost	$579.2	$961.7	66.0%
Procurement cost	$7,238.9	$5,383.3	-25.6%
Total program cost	$7,818.1	$6,354.4	-18.7%
Program unit cost	$5.117	$5.814	13.6%
Total quantities	1,528	1,093	-28.5%
Acquisition cycle time (months)	N/A	148	N/A

Change in acquisition cycle time could not be calculated as initial estimates did not include an initial operational capability date.

The program entered production in March 2014 with mature technologies and a stable design, but before bringing manufacturing processes under control. Prior to its production decision, the program demonstrated its manufacturing processes on a pilot production line and tested a production-representative prototype. The PATRIOT system requires additional upgrades to fully test and utilize all the PAC-3 MSE capabilities prior to full-rate production of the missile. This testing was delayed over a year due to limited access to PATRIOT test assets. Further schedule impacts will be mitigated by a dedicated PATRIOT test battalion returning from deployment. In 2015, the program definitized its production contract after several delays, accepted delivery of the first PAC-3 MSE missiles, received approval to conditionally field the missiles, and equipped its first unit.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	○
• Demonstrate critical processes on a pilot production line	●
• Test a production-representative prototype	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

PAC-3 MSE Program

Technology and Design Maturity

The PAC-3 MSE will begin operational testing in the fourth quarter of fiscal year 2016 with mature technologies and a stable design. While the PAC-3 MSE has components that are 90 percent common with the earlier variant, there were four unique technologies critical to PAC-3 MSE that required development: a dual pulse solid rocket motor, thermal batteries, an ignition safety device, and insensitive munition improvements to prevent inadvertent launch or detonation.

Production Maturity

PAC-3 MSE began production in March 2014 after testing a production-representative prototype and demonstrating manufacturing processes on a pilot production line, but before demonstrating critical processes to be in control. Prior to its production decision, the program's manufacturing readiness was at the level recommended by DOD guidance, but it did not reach the level that indicated processes were in control as recommended by GAO best practices. Program officials expect to achieve this higher level prior to the full-rate production decision.

Other Program Issues

The PAC-3 MSE program received approval to begin producing missiles for launch from the current PATRIOT system software and hardware configuration. However, upgrades to this software and hardware are needed to fully test and utilize all the PAC-3 MSE capabilities prior to full-rate missile production. Operational testing of these upgrades was delayed over a year until the fourth quarter of fiscal year 2016 due to the limited availability of test assets caused by the operational deployment of a PATRIOT test battalion as well as reallocation of PATRIOT test assets for use in the Army's Integrated Air and Missile Defense program. In August 2015, the program office was able to fully address the equipment and manning issues when it secured a dedicated test battalion, returning from deployment, to support both Integrated Air and Missile Defense and PATRIOT test and evaluation requirements. The program plans to revise its test plan by the second quarter of fiscal year 2016 to reflect the new test dates leading up to a full-rate production decision.

In October 2015, the PAC-3 MSE program definitized its production contract after several delays and then completed all necessary steps to equip its first PATRIOT unit. Production of the PAC-3 MSE began under an undefinitized contract action issued in March 2014 as a short-term vehicle to allow the program to change the production contract from a firm-fixed-price to a fixed-price incentive (firm target) contract. This change was also in alignment with DOD's Better Buying Power initiatives. Agreement on final contract pricing and terms was delayed by more than a year past its expected definitization date for several reasons, including the incorporation of changes to the cost analysis and pricing methodologies. We have reported in the past that delays in finalizing this type of contract places the program at risk of cost growth, as the government normally reimburses contractors for all allowable costs incurred during the undefinitized period, giving contractors little incentive to control costs. In October 2015, the program definitized the contract, received the first 12 missiles from the contractor, and received approval for conditional fielding of the missiles. By the end of the month, the program had successfully equipped the first PATRIOT unit with these missiles.

Program Office Comments

In commenting on a draft of this assessment, the Army provided technical comments, which were incorporated as appropriate.

Warfighter Information Network-Tactical (WIN-T) Increment 2

WIN-T is the Army's high-speed and high-capacity tactical communications network. It connects units with higher levels of command and is being fielded in several increments. The second increment is expected to provide the Army with required networking on-the-move capability. The third increment is now a software-only development effort that will provide critical software upgrades to support improved network capabilities for the first and second increments.

Source: U.S. Army.

Concept | **System development** | **Production**

- Program/development start (6/07)
- Design review (2/08)
- Low-rate decision (3/10)
- Initial operational testing (5/12)
- Follow-on operational test (5/13)
- Initial capability (8/13)
- Follow-on operational test (11/14)
- Full-rate decision (6/15)
- GAO review (1/16)

Program Essentials

Prime contractor: General Dynamics C4 Systems, Inc.
Program office: Aberdeen Proving Ground, MD
Funding needed to complete:
R&D: $4.2 million
Procurement: $7,157.5 million
Total funding: $7,161.7 million
Procurement quantity: 2,372

Program Performance (fiscal year 2016 dollars in millions)

	As of 10/2007	Latest 09/2015	Percent change
Research and development cost	$256.0	$287.4	12.3%
Procurement cost	$3,722.5	$10,060.1	170.2%
Total program cost	$3,978.5	$10,347.5	160.1%
Program unit cost	$2.102	$2.774	32.0%
Total quantities	1,893	3,730	97.0%
Acquisition cycle time (months)	50	74	48.0%

WIN-T Increment 2 entered production in March 2010 with its critical technologies mature and, according to program officials, a stable design. The program had struggled to demonstrate the required performance and reliability during earlier rounds of operational testing, and a third operational test concluded in November 2014 identified that, while the program has demonstrated continued reliability growth, certain deficiencies remained. The program reported a Nunn-McCurdy unit cost breach of the significant threshold in January 2015 due to changes in the relative mix of items procured and a 10 year schedule extension. In June 2015, DOD approved the program to start full-rate production, assigned affordability caps on unit costs, and directed the program to take actions to address performance issues.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	····
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	●
• *Demonstrate critical processes on a pilot production line*	
• Test a production-representative prototype	●

● Knowledge attained
○ Knowledge not attained
···· Information not available
Not applicable

WIN-T Increment 2 Program

Technology, Design, and Production Maturity

All 15 WIN-T Increment 2 critical technologies were mature by its March 2010 production start. The program office does not track the metric we use to measure design maturity–the number of releasable drawings–as WIN-T is primarily an information technology integration effort. Instead, design performance is measured through a series of component, subsystem, configuration item, and network-level tests designed to demonstrate performance at increasing levels of system integration. According to the WIN-T program, it has integrated and tested its key technologies and subsystems, demonstrating that the system's design is capable of working as intended and is mature. The program began testing a production-representative prototype in March 2011 and assessed its manufacturing processes as in control in 2012, both after production began.

Other Program Issues

The program struggled to demonstrate the required performance and reliability during earlier rounds of operational testing. A third operational test, which concluded in November 2014, showed improved reliability and performance compared to prior tests but found that deficiencies remain. In particular, while many of the program's components have now been assessed as operationally effective and suitable, two were assessed as not operationally effective due to the limits of one waveform used for communications. The Stryker variants of two other components were assessed as not operationally suitable due to significant integration and user issues that interfered with a unit's ability to operate. The most recent operational tests also found that the program has significant cyber security deficiencies. As a result, the Under Secretary of Defense for Acquisition, Technology, and Logistics directed the Army to perform an independent cyber design and implementation assessment. Cyber security vulnerabilities reduced the program's operational capacity and could incur cost growth and schedule delays if significant changes are necessary. According to program officials, the independent assessment is complete and was provided to the Under Secretary of Defense for Acquisition, Technology, and Logistics in October 2015.

In January 2015, the Army announced that the program had experienced a significant Nunn-McCurdy cost breach due to increased unit costs. The Army stated that, as a result of changes in the Army network modernization strategy, there have been changes in the relative mix of items it is procuring to include a higher percentage of more expensive items. In addition, the WIN-T Increment 2 procurement schedule was extended by 10 years to support fielding requirements as part of the WIN-T Increment 3 restructure. Program officials told us future unit cost growth remains an ongoing concern. The program could be at risk of an additional unit cost breach if there are significant quantity changes in the future.

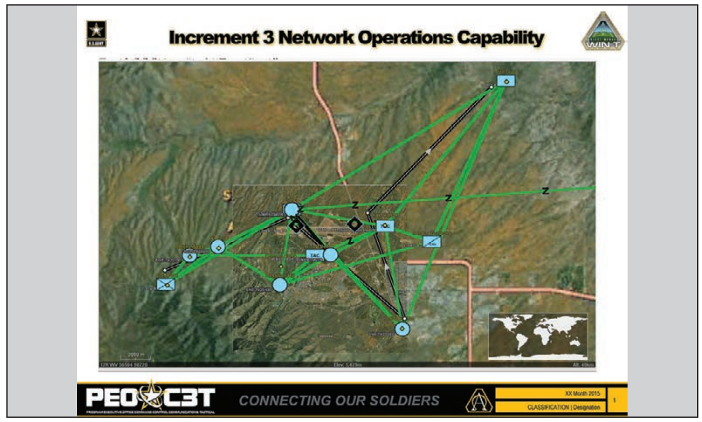
The Under Secretary of Defense for Acquisition, Technology, and Logistics approved the program to enter full-rate production in June 2015. He also directed the program to take corrective actions to address the performance deficiencies and cyber security vulnerabilities discovered in testing and established affordability caps on the program's unit costs. According to program officials, each of these corrective actions has either been completed or is under way.

Program Office Comments

In addition to providing technical comments, the program office stated it has developed corrective action plans to address issues identified in the full-rate acquisition decision memorandum–Stryker integration and limitations of one waveform used for communications. Testing has demonstrated improvements in cyber security, but certain issues remain. The program is addressing and executing cyber security issues with defined short, mid and long-term mitigation steps. The Army continues fielding to priority units–a total of 5 divisions and 14 brigade combat teams have been fielded through early fiscal year 2016, and the program is now making improvements to network initialization and integration of WIN-T systems to help enable airborne operations.

Warfighter Information Network-Tactical (WIN-T) Increment 3

WIN-T is the Army's high-speed and high-capacity communications network. It connects units with higher levels of command and is being fielded in several increments. Increment 3, the increment assessed here, provides software enhancements to the Army's communication for improved network capacity and robustness. This software will be used to update and enhance hardware procured for the first and second increments.



Source: U.S. Army.

Concept | **System development/Production**

- Program/ development start (7/03)
- Design review (12/13)
- Restructure finalized (9/14)
- GAO review (1/16)
- Limited user test complete (5/16)

Program Essentials

Prime contractor: General Dynamics C4 Systems, Inc.
Program office: Aberdeen Proving Ground, MD
Funding needed to complete:
- R&D: $38.7 million
- Procurement: $0.0 million
- Total funding: $38.7 million
- Procurement quantity: 0

Program Performance (fiscal year 2016 dollars in millions)

	As of 05/2009	Latest 09/2015	Percent change
Research and development cost	$2,883.2	$2,024.6	-29.8%
Procurement cost	$14,677.2	$0.0	-100.0%
Total program cost	$17,560.4	$2,024.6	-88.5%
Program unit cost	$5.043	N/A	N/A
Total quantities	3,482	0	-100.0%
Acquisition cycle time (months)	165	N/A	N/A

In May 2014, the Under Secretary of Defense for Acquisition, Technology, and Logistics approved the Army's request to restructure the WIN-T Increment 3 program, which eliminated the requirements for hardware but retained the software development efforts to update WIN-T Increments 1 and 2. As a result, the program is reporting fewer critical technologies, and the remaining technologies are intended to improve network operations and increase the throughput available for satellite communications. The Army plans to continue software development and testing through fiscal year 2016. Upon completion, WIN-T Increment 3 will cease to be an independent acquisition program, and the WIN-T Increment 1 and Increment 2 programs will complete the software integration, operational testing, and fielding.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• *Release at least 90 percent of design drawings*	
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

WIN-T Increment 3 Program

Technology Maturity

As we previously reported, the Army restructured the program in 2014 and descoped the technologies associated with hardware development, including the digital transceiver and antennas. As a result, WIN-T Increment 3 is now a software-only development program, with development and testing continuing through fiscal year 2016. While the remaining technologies improve network operation by simplifying network management, increasing automation, and boosting throughput and robustness, the current program development path will eliminate the expected increase in network density allowed by descoped hardware. According to program officials, by eliminating aircraft-based antenna hardware more data will have to be transmitted via satellite, which is both expensive and can be interrupted via jamming. Officials also stated, however, that the requirement for this capability has been deferred due to the cost, given the current budget environment, rather than eliminated completely. The program office considers its remaining technologies mature. Some of the critical technologies may be replaced by backup technologies, however, the decision on whether or not to do so will not occur until after a Network Integration Exercise currently scheduled for spring 2016. The WIN-T Increment 1 and Increment 2 programs will complete the integration, operational testing, and fielding of the WIN-T Increment 3 software.

Design and Production Maturity

The program office does not track the metric we use to measure design maturity–the number of releasable drawings as WIN-T Increment 3 is a software-only development program. Instead, design performance is measured using earned value management data that tracks the progress of work completed against projected cost and schedule estimates. According to the program office, it is not meeting the projected estimates. Officials stated that they also use incident reports and the closure rate of those reports to track progress. With the elimination of WIN-T Increment 3's unique hardware development no production is required.

Other Program Issues

According to program documentation, the restructuring of the WIN-T program was due to fiscal constraints that forced the Army to adjust its funding priorities and requirements. The program will continue submitting defense acquisition executive summaries and selected acquisition reports until its capabilities are incorporated into WIN-T Increments 1 and 2. After the program provides the planned capabilities in fiscal year 2016, it will cease to be an independent acquisition program.

Program Office Comments

The program office concurred with this assessment and provided technical comments, which were incorporated where appropriate.

Indirect Fire Protection Capability Increment 2-Intercept Block 1 (IFPC Inc. 2-I Block 1)

The Army's IFPC Inc. 2-I is a follow-on effort to enhance and extend the range of the first IFPC increment fielded in 2004, which provided a short-range capability to counter threats from rockets, artillery, and mortars. IFPC Inc. 2-I is being developed in three blocks, each a separate major defense acquisition program. Block 1 adds the capability to counter cruise missiles and unmanned aircraft. The remaining blocks enhance and extend the range of IFPC's capabilities to defend against these various threats. We assessed Inc. 2-I Block 1.

Source: IFPC Inc 2 Product Office.

Current Status

The IFPC Inc. 2-I Block 1 program is developing a multi-mission launcher (MML) capable of launching at least six different types of missiles. According to program officials, the Army intends to leverage existing sensors, interceptors, and network capabilities and integrate them with the launcher to deliver a system-of-systems air defense capability. Based on the Army's determination that in-house development of the MML is estimated to cost less than developing prototypes through one or more contractors, all development will take place at two Army facilities, the Aviation and Missile Research, Development, and Engineering Center (AMRDEC) and Letterkenny Army Depot (LEAD). The Army has completed the assembly of two MML prototypes and is currently integrating them with the other existing systems necessary for deployment of an initial operational capability. The program entered technology development in March 2014 and a year later successfully launched three different types of missiles from its prototype. In March 2016, the program plans to assess the system's maturity by launching multiple types of missiles from the MML during an engineering demonstration. If this demonstration is successful, according to program officials, all technologies will be at least approaching full maturity by the start of system development.

According to program officials, the IFPC Inc. 2-I Block 1 program held a successful preliminary design review in September 2015 and was granted approval to proceed to a system development start in June 2016 and critical design review in September 2016. In January 2015, the program completed a cost-benefit analysis to determine a strategy for development. Among the alternatives reviewed were continuing the exclusive use of Army facilities, full and open competition among contractors, a public-private partnership between the Army facilities and a contractor, or some combination. The analysis concluded that continuing to use the Army's facilities at AMRDEC and LEAD exclusively would be the least expensive alternative. The program is required to conduct a similar analysis to evaluate strategies for production.

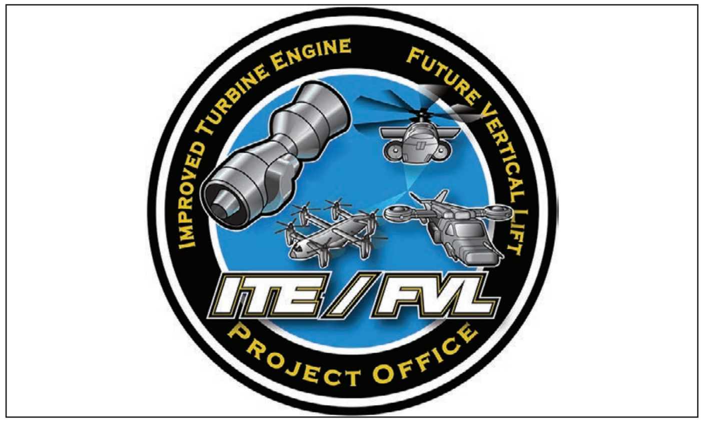
Estimated Program Cost and Quantity (fiscal year 2016 dollars):
Total program: $2.6 billion
Research and development: $522 million
Procurement: $2.1 billion
Quantity: 8 (development), 360 (procurement), 368 (total)

Next Major Program Event: System development start, June 2016

Program Office Comments: In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

Improved Turbine Engine Program (ITEP)

The Army's Improved Turbine Engine Program (ITEP) is developing a replacement engine for the Black Hawk and Apache helicopter fleets. The new engine is designed for increased power, performance, and fuel efficiency; enhanced reliability; increased service life; and a lower maintenance burden than current engines. The increased fuel efficiency is expected to lessen the need for refueling by providing increased operational range. The Army plans to begin fielding these engines in fiscal year 2027.



Source: U.S. Army.

Current Status

In November 2012, ITEP entered the material solution analysis phase and conducted an analysis of alternatives. During that phase, two contractors developed component prototypes to mature technologies, design and manufacture prototype components, perform component assembly, and conduct demonstrations. Subsequently, an independent review team determined that the three critical technologies—advanced inlet particle separator, compressor/advanced aerodynamics, and hybrid bearings—were approaching full maturity.

In June 2015, the Under Secretary of Defense for Acquisition, Technology, and Logistics approved the program's entry into the technology maturation and risk reduction phase as a major defense acquisition program. ITEP plans to award two fixed-price incentive (firm target) preliminary design review contracts to establish the baseline of the engine system and sub-elements, obtain information regarding cost, and further demonstrate technologies. According to officials, the expected value of these contracts represents approximately one-fifth of the program's total estimated research and development cost.

The Army has identified moderate risks associated with increased life cycle costs, key performance parameters, and platform integration requirements. However, mitigation plans are in place and the Army does not expect them to impact system development. Following completion of the planned preliminary design review in the first quarter of fiscal year 2018, the Army intends to award a cost-plus-incentive-fee contract for system development. Competition for this contract will be limited to the two contractors awarded preliminary design contracts.

Estimated Program Cost and Quantity (fiscal year 2016 dollars):
Total program: $10,011.0 million
Research and development: $1,852.9 million
Procurement: $8,158.1 million
Quantity: 68 (development), 6,215 (procurement)

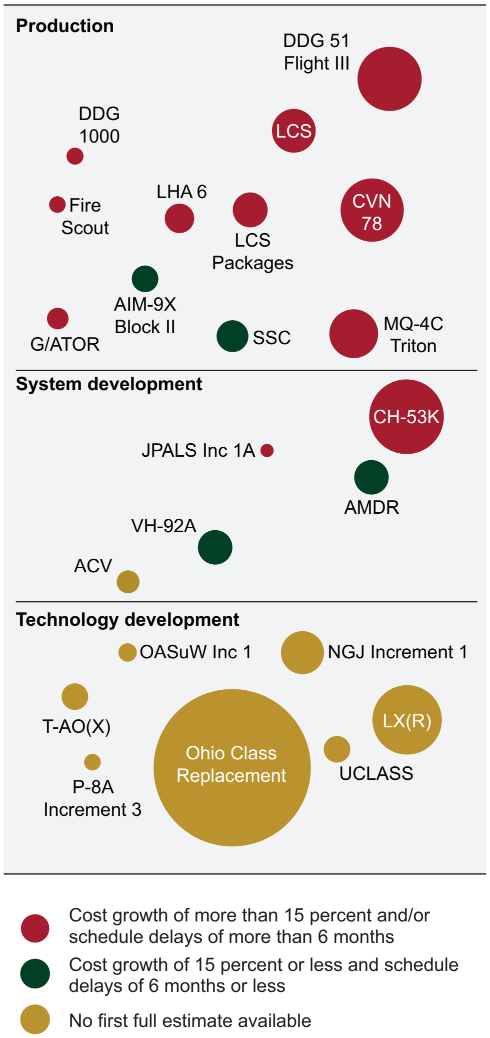
Next Major Program Event: Technology maturation and risk reduction start, April 2016

Program Office Comments: According to the Army, preliminary design request for proposals was released in September 2015 with an anticipated award in fourth quarter fiscal year 2016. In addition, technical comments were incorporated as appropriate.

Navy and U.S. Marine Corps Service Summary

We performed in-depth assessments on 15 of the 35 Navy and Marine Corps programs in the current portfolio currently between the start of development and the early stages of production. In addition, we assessed the Amphibious Combat Vehicle which began system development in November 2015 and another seven programs identified as future major defense acquisition programs which are expected to enter system development in the next few years. The Navy and Marine Corps currently estimate a need of more than $213 billion in funding to complete the acquisition of these 23 programs. The programs currently in the portfolio for which we determined cost and schedule change from first full estimates have experienced approximately $117 billion in cost growth, the majority of which occurred more than five years ago, and average schedule delays of 40 months. Of the programs in the current portfolio where a two-page assessment was prepared, two have completed all the activities associated with the applicable knowledge based best practices we assess.

Acquisition Phase and Size of the 23 Programs Assessed

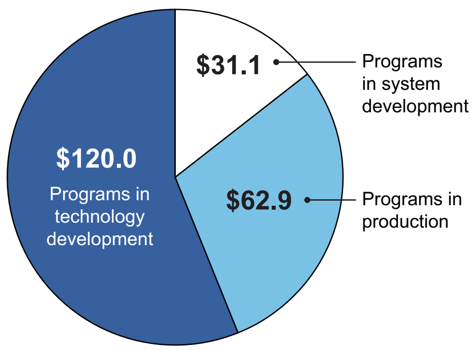


Note: Bubble size is based on each program's currently estimated future funding needed.

Source: GAO analysis of DOD data. | GAO-16-329SP

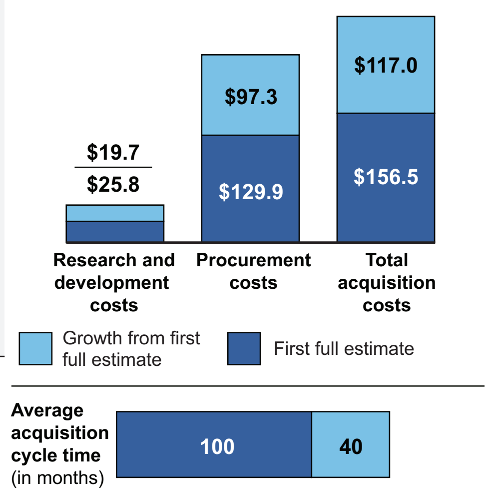
Currently Estimated Acquisition Cost for the 23 Programs Assessed

Fiscal year 2016 dollars in billions



Cost and Schedule Growth on 15 Programs in the Current Portfolio

Fiscal year 2016 dollars in billions



Note: In addition to research and development and procurement costs, total acquisition cost includes acquisition related operations and maintenance and system-specific military construction costs.

Summary of Knowledge Attained to Date for Programs Beyond System Development Start

Program common name	Knowledge Point (KP) 1 Resources and requirements match	Knowledge Point 2 Product design is stable	Knowledge Point 3 Manufacturing processes are mature
AIM-9X Block II	●	●	●
AMDR	○	●	KP 3 in future
ACV	○	○	KP 3 in future
CH-53K	●	- - -	KP 3 in future
DDG 1000	○	●	■
CVN 78	○	●	■
G/ATOR	●	●	○
JPALS Inc 1A	○	○	KP 3 in future
LHA 6	●	■	■
LCS	○	●	■
LCS Packages	○	■	■
MQ-4C Triton	●	●	○
Fire Scout	●	●	- - -
SSC	●	○	○
VH-92A	○	KP 2 in future	KP 3 in future

● All applicable knowledge practices were completed

○ One or more applicable knowledge practices were not completed

■ All knowledge practices were not applicable

- - - Information not available for one or more knowledge practice

Note: The DDG 51 Flight III Destroyer is excluded from the summary above since we only present our observations about the program in a 1-page assessment format.

Navy and Marine Corps Program Assessments

AIM-9X Block II Air-to-Air Missile (AIM-9X Block II)

The AIM-9X Block II is a Navy-led program to acquire short-range air-to-air missiles for the F-35, the Navy's F-18, and the Air Force's F-15, F-16, and F-22A fighter aircraft. It is designed to detect, acquire, intercept, and destroy a range of airborne threats. Block II includes hardware and software upgrades intended to improve the range from which the AIM-9X can engage targets, target discrimination, and interoperability. It was designated a major defense acquisition program in 2011.

Source: U.S. Navy.

Concept | System development | Production

- Program start (2004)
- Preliminary design review (3/07)
- Critical design review (9/07)
- Low-rate decision (6/11)
- Operational test complete (3/15)
- Initial capability (3/15)
- Full-rate decision (8/15)
- GAO review (1/16)

Program Essentials

Prime contractor: Raytheon Missile Systems
Program office: Patuxent River, MD
Funding needed to complete:
R&D: $335.7 million
Procurement: $2,113.5 million
Total funding: $2,449.2 million
Procurement quantity: 4,432

Program Performance (fiscal year 2016 dollars in millions)

	As of 12/2011	Latest 07/2015	Percent change
Research and development cost	$182.4	$550.6	201.9%
Procurement cost	$4,104.3	$2,955.4	-28.0%
Total program cost	$4,286.7	$3,506.0	-18.2%
Program unit cost	$0.714	$0.584	-18.2%
Total quantities	6,000	6,000	0.0%
Acquisition cycle time (months)	39	45	15.4%

The AIM-9X Block II entered production in June 2011 with mature critical technologies, a stable and demonstrated design, and production processes that had been demonstrated on a production line but were not in control. In July 2013, the Navy suspended operational testing due to missile performance issues. The program resumed operational testing in June 2014 after identifying root causes and fixes for these issues, and completed testing in March 2015. The system was found to be operationally effective and suitable and the program received approval to enter full-rate production in August 2015, more than a year later than initially planned. The AIM-9X Block II program office is working to resolve additional minor deficiencies with the missile identified during testing; aircraft program offices are working to address integration issues.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	●
• Demonstrate critical processes on a pilot production line	●
• Test a production-representative prototype	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

AIM-9X Block II Program

Technology and Design Maturity

AIM-9X Block II entered operational testing with its critical technologies mature and its design stable and demonstrated. According to the Navy's May 2011 technology readiness assessment, Block II involves the integration of mature technologies, including a new active optical target detector/datalink, an upgraded electronics unit, and new operational flight software. The program estimates that 85 percent of Block II components are unchanged from Block I. The Navy suspended operational testing on the AIM-9X Block II in July 2013 due to missile performance deficiencies related to hardware in the inertial measurement unit and concerns about the missiles target acquisition time, which required a minor hardware upgrade and a software fix. The contractor delivered solutions to these issues in January 2014 and the program re-entered operational testing in June 2014. AIM-9X Block II competed operational testing in March 2015 and was found to be operationally effective and suitable. While issues from the prior round of testing were resolved, the recent testing identified four additional deficiencies related to reliability, software, and performance of the missile as well as five major deficiencies related to aircraft integration which are being addressed by the aircraft program offices. Program officials said that most of the missile deficiencies will be corrected with the next software update scheduled for 2020. The major integration failures will be corrected in early 2016 through a software upgrade on F-18 aircraft.

Production Maturity

AIM-9X Block II began production in June 2011, with manufacturing processes that had been demonstrated on a pilot production line but were not in control. Since the start of production, the program has further matured its processes, and program officials stated that they are now at a manufacturing readiness level that indicates they are in control. In the most recent operational testing, a production process deficiency caused a misfire. Program officials said that this is related to quality issues in the production line, which they have addressed through additional quality assurance procedures, and a potential reliability issue related to the ignition safety device. The program is still determining the root cause of this issue.

Other Program Issues

The suspension of operational testing delayed the program's full-rate production decision from April 2014 to August 2015. Production of AIM-9X Block II continued during the suspension of operational testing, but the program office said they did not accept the delivery of any additional missiles until April 2015, when the issues were resolved and the units had been retrofitted. In total 18 percent of the total quantities were procured prior to the full rate production and have been retrofitted to correct the issues found in both iterations of operational testing.

The AIM-9X Block III program was cancelled in fiscal year 2014. However, funding for several of the Block III planned improvements, including increased lethality, enhanced infra-red countermeasures, and improved insensitive munitions performance, was moved to the AIM-9X Block II program, as part of the System Improvement Program III (SIP III). A $312 million contract for this effort was awarded in September 2015.The contract for this program will also address component obsolescence and implement cost reduction initiatives.

Program Office Comments

In commenting on a draft of this assessment, program officials stated that the AIM-9X Block II missile development program was highly successful, bringing changes that were implemented to address obsolescence and providing a greatly increased performance envelope over the previous AIM-9X missile design. According to officials, while the program experienced testing delays, changes to hardware and software resulted in significant performance improvements, verified with laboratory, ground, flight and live fire testing. The program office also provided technical comments, which were incorporated where deemed necessary.

Air and Missile Defense Radar (AMDR)

The Navy's AMDR is a next-generation radar program designed to support surface warfare and integrated air and missile defense. AMDR is developing an S-band radar for ballistic missile and air defense and a radar suite controller to provide radar resource management, coordination, and interface to the combat system to support DDG 51 Flight III ships. For horizon search capability, the Navy plans to use an existing X-band radar for the first 12 DDG 51 Flight III ships, with a future X-band radar program expected to support subsequent ships.

Source: U.S. Navy.

Concept		System development					Production	
Program start (9/10)	Development start (9/13)	Preliminary design review (8/14)	Critical design review (4/15)	GAO review (1/16)	Low-rate decision (9/17)		Start operational test (6/23)	Initial capability (9/23)

Program Essentials

Prime contractor: Raytheon
Program office: Washington, DC
Funding needed to complete:
R&D: $551.4 million
Procurement: $3,408.8 million
Total funding: $3,960.2 million
Procurement quantity: 22

Program Performance (fiscal year 2016 dollars in millions)

	As of 10/2013	Latest 07/2015	Percent change
Research and development cost	$1,945.0	$1,793.0	-7.8%
Procurement cost	$4,022.7	$3,408.8	-15.3%
Total program cost	$5,997.8	$5,231.6	-12.8%
Program unit cost	$272.627	$237.801	-12.8%
Total quantities	22	22	0.0%
Acquisition cycle time (months)	155	155	0.0%

AMDR completed critical design review in April 2015, with its four critical technologies approaching full maturity and its design stable. Two of four planned software builds have been completed, with the other two builds expected to be completed by September 2016. The contractor is finalizing a full-scale radar array prototype, which is scheduled to begin land-based testing at the Navy's Pacific Missile Range Facility in summer 2016.The Navy's plans for the program do not include testing the radar system at sea until after it is installed on a DDG 51 Flight III ship. The AMDR test and evaluation master plan has not been approved by DOD's Director, Operational Test and Evaluation (DOT&E), and no approval is expected until use of an unmanned self-defense test ship is incorporated into operational testing.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

AMDR Program

Technology and Design Maturity

AMDR's four critical technologies–digital-beam-forming, transmit-receive modules, software, and digital receivers/exciters–are nearing full maturity, and the program is expected to deliver its first radar to DDG 51 Flight III, as scheduled, in spring 2020. The contractor completed developmental testing of an early prototype consisting of key subsystems in July 2012. In April 2015, the program office completed a critical design review, with 100 percent of design drawings finalized and releasable. To support initial integration between the radar and the combat system, the AMDR contractor developed and delivered an AMDR simulator to the combat system contractor in September 2015. The AMDR contractor is also developing a radar emulator–scheduled to be completed in spring 2016–that is intended to support system testing and early combat system software integration. The simulator and emulator are expected to help inform the program's knowledge of the radar and combat system interface performance prior to a 6-month risk reduction test period planned for the second half of fiscal year 2017.

Additionally, the contractor has built and tested a second prototype at its facility, which is a single 14-foot S-band radar array–the final configuration for DDG 51 Flight III ships will be a four-faced array. In July 2016, this prototype is expected to be delivered to the Navy's Pacific Missile Facility (PMF) in Hawaii for testing in a more representative environment. The Navy has allotted 15 months in the AMDR schedule to install this asset at the lab and complete test activities prior to a low-rate initial production decision in September 2017. This production decision will be made prior to combat system integration and test, so any design issues identified through testing will have to be addressed during production.

The AMDR program includes significant software development, which is being completed in four builds. The software approach includes upfront requirements and architecture analysis for each build, as well as continuous integration of new software and automated testing to ensure functionality and performance. The first two already completed developed basic infrastructure, anti-air warfare, and ballistic missile defense capabilities. The third and fourth builds are intended to provide the full extent of radar capabilities, including debris detection and mitigation and advanced discrimination of missile threats. Build three is scheduled to be completed in January 2016 and the final build completion is planned for September 2016. The Navy also has approved plans to upgrade the combat system for integration with AMDR, but the requirements for the upgrade have not yet been defined. The interface between AMDR and the combat management system will require a significant software development effort, with software builds expected to be completed in fiscal year 2021.

Other Program Issues

In 2013, DOT&E disapproved AMDR's Test and Evaluation Master Plan because of operational realism concerns, noting that use of an unmanned AMDR– and Aegis–equipped self-defense test ship is needed to ensure adequate operational testing. No decision has been made on whether a test ship will be used for the testing. If a test ship is used, early DOD estimates suggest that operational testing costs will increase by $300 to $400 million.

Program Office Comments

In commenting on a draft of this assessment, the Navy stated they intend to complete the requirements for the upgrade of the combat system for integration with AMDR by the fall of 2016. The program also provided technical comments, which were incorporated as appropriate.

Amphibious Combat Vehicle (ACV)

The Marine Corps' ACV is the successor program to the canceled Expeditionary Fighting Vehicle. The ACV is intended to transport Marines from ship to shore and provide armored protection on land. It will potentially replace all or a portion of the existing Assault Amphibious Vehicle fleet. The ACV acquisition approach calls for three increments of development–1.1, 1.2, and 2.0–with increasing amphibious capability provided by each successive increment. We assessed the first increment, ACV 1.1.

Source: U.S. Marine Corps.

Concept | System development | Production

- Program start (6/14)
- Development start (11/15)
- GAO review (1/16)
- Design review (2/16)
- Low-rate decision (2/18)
- Initial capability (8/20)
- End operational test (11/20)
- Full capability (7/23)

Program Essentials

Prime contractor: TBD
Program office: Stafford, VA
Funding needed to complete:
- R&D: $632.8 million
- Procurement: $1,111.9 million
- Total funding: $1,769.4 million
- Procurement quantity: 204

Program Performance (fiscal year 2016 dollars in millions)

	As of	Latest 07/2015	Percent change
Research and development cost	N/A	$904.0	N/A
Procurement cost	N/A	$1,111.8	N/A
Total program cost	N/A	$2,040.5	N/A
Program unit cost	N/A	$8.502	N/A
Total quantities	N/A	240	N/A
Acquisition cycle time (months)	N/A	57	N/A

While the ACV program considers both of its critical technologies to be fully mature, one of the technologies has not been demonstrated in the ACV's operational environment. The program does not plan to hold a preliminary design review before the start of system development and will instead combine it with the critical design review scheduled for February 2016. Eliminating preliminary design review before system development start may limit knowledge gained and increase risk. The program also plans to conduct concurrent testing and production that could leave it at risk for design changes after production begins, as well as costly retrofits, if deficiencies are found during testing. The program awarded two development contracts in November 2015; however, contract performance has been delayed by a bid protest filed with GAO.

Attainment of Product Knowledge

Projected as of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	Knowledge attained
• Demonstrate all critical technologies in an operational environment	Knowledge not attained
• Complete preliminary design review	Knowledge not attained
Product design is stable	
• Release at least 90 percent of design drawings	Knowledge attained
• Test a system-level integrated prototype	Knowledge not attained
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

ACV Program

Technology Maturity

While the ACV 1.1 program considers its critical technologies fully mature, one of the technologies has not yet been demonstrated in the ACV's operational environment. A December 2014 technology readiness assessment identified two critical technology elements and considered both to be mature. One critical technology–drivers vision enhancement–was considered fully mature since it employs an existing system used on the Amphibious Assault Vehicle. The second critical technology–the remote weapon station–was also assessed as mature. However, this technology has not been demonstrated in the marine environment, in which the ACV is expected to operate. As a result, the technology could entail a higher level of risk and may require additional testing as development begins. Development of future increments of ACV will require new technologies beyond those included in the first increment.

Design Maturity

The ACV program planned to hold a preliminary design review and critical design review about three months after system development start. As the development contracts are the subject of a bid protest, that event will likely be delayed. A preliminary design review is typically required before development begins. Best practices recommend this step to ensure that design requirements and cost and schedule estimates are informed by this review before committing to system development. Bypassing this review before system development may limit the knowledge gained and increase cost and schedule risk. According to the program office, officials expect that 90 percent of engineering drawings will be completed by critical design review, in alignment with best practices. However, combining the preliminary and critical design reviews may limit the time available to the program to address any issues identified and ensure that sufficient knowledge is attained prior to system demonstration.

Production Maturity

The current ACV program schedule includes concurrency between testing and production that could increase program risk, with approximately 10 months of system-level developmental testing expected after the start of production. According to program officials, enough developmental testing, and a required operational assessment, will be completed to support the production decision planned for February 2018. Both DOD acquisition policy and our prior work acknowledge that some degree of concurrency between initial production and developmental testing may be necessary. However, our past work has also shown that beginning production before demonstrating that a design is mature and will work as intended increases the risk of discovering deficiencies during production that could require substantial design changes, costly modifications, and retrofits to vehicles already built.

Other Program Issues

The ACV acquisition approach included competition through competitive prototyping prior to the start of system development and will continue competition through development and production. The program awarded development contracts to two contractors in November 2015, and plans to maintain competition until the start of production for the ACV 1.1 variant. However, contract performance has been delayed pending the resolution of issues raised in a bid protest filed with GAO.

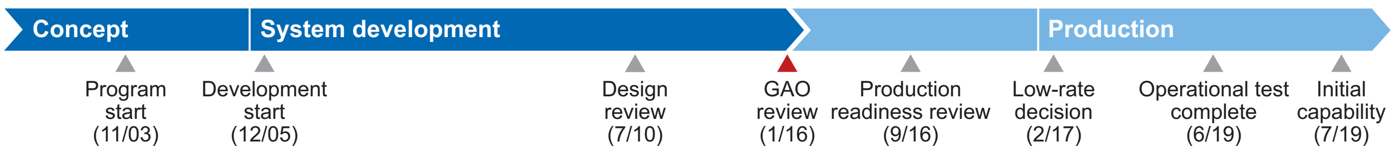
Program Office Comments

In commenting on a draft of this assessment, program officials noted that the latest cost data reported in this assessment are based on a program manager's estimate and cannot be finalized until the ACV's acquisition program baseline–the first full cost and schedule estimates generally established at system development start–is approved.

CH-53K Heavy Lift Replacement Helicopter (CH-53K)

The Marine Corps' CH-53K heavy-lift helicopter is intended to transport armored vehicles, equipment, and personnel to support operations deep inland from a sea-based center of operations. The CH-53K is expected to replace the legacy CH-53E helicopter and provide increased range and payload, survivability and force protection, reliability and maintainability, and coordination with other assets, while reducing total ownership costs.

Source: Sikorsky Aircraft Corporation.



Program Essentials

Prime contractor: Sikorsky Aircraft Corporation
Program office: Patuxent River, MD
Funding needed to complete:
- R&D: $1,581.8 million
- Procurement: $18,935.6 million
- Total funding: $20,521.9 million
- Procurement quantity: 194

Program Performance (fiscal year 2016 dollars in millions)

	As of 12/2005	Latest 07/2015	Percent change
Research and development cost	$4,698.2	$6,755.0	43.8%
Procurement cost	$13,066.4	$18,935.6	44.9%
Total program cost	$17,764.6	$25,708.2	44.7%
Program unit cost	$113.876	$128.541	12.9%
Total quantities	156	200	28.2%
Acquisition cycle time (months)	119	163	37.0%

The CH-53K conducted its first flight in October 2015, and the program's two critical technologies –housed within the main rotor blade and main gearbox–have begun testing in an operational environment. While the program completed its critical design review more than 5 years ago, unexpected redesigns to critical components have delayed aircraft assembly and testing and have slowed delivery of test aircraft. As a result of these issues, the program's low-rate initial production decision has been delayed again to February 2017–approximately 8 additional months since our last assessment. To date, two of the five test aircraft have been delivered, the third is complete but has not yet begun flight testing, and the remaining two have been delayed due to unexpected redesigns. Achieving initial capability is now expected nearly 4 years later than planned due to these challenges.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	••••
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
•••• Information not available
Not applicable

CH-53K Program

Technology and Design Maturity

The CH-53K conducted its first flight in October 2015–nearly 3 years later than originally planned and has logged a number of test flights to date. As a result of this testing, the program's two critical technologies–housed within the main rotor blade and main gearbox–have begun testing in an operational environment. Reaching this point more than 5 years after the program's critical design review and nearly 10 years after system development start is not consistent with best practices.

Unanticipated design changes to non-critical technology components after critical design review continue to cause flight test and production delays. For example, components within the rear module assembly, part of the main gear box, required a number of redesigns. Most recently, equipment that holds one of the gears in place failed, which required a reconfiguration of the rear module assembly retention design. The new design has been completed and installed on the ground test vehicle and the second flight test aircraft, which is expected to achieve its initial flight in early 2016. The redesigned gear box will also be installed in the next two flight test aircraft, but has not yet been installed in the current flight test aircraft. The current flight test aircraft uses the prior design and will be held to a flight life limitation. Schedule delays also occurred due to late component deliveries and qualification issues for the main rotor blades, main rotor head, and tail rotor blades. The program continues to monitor and mitigate these delays when possible. The failure to demonstrate technology and design maturity at appropriate points earlier in system development is one reason why the CH-53K program now expects to reach its initial operational capability in late 2019, nearly 4 years later than originally planned.

Production Maturity

To date the CH-53K program has taken delivery of the ground test vehicle with the redesigned main gear box, and the first flight test aircraft. The second flight test aircraft is complete and has undergone installation of the redesigned main gear box but has not yet begun flight tests. The unexpected redesigns of the aircraft's various gear boxes as well as the late delivery of some components have delayed delivery of the remaining two engineering design model test aircraft. This has created delays at the production facility where parts are received from vendors, which is expected to impact the flight test schedule.

As a result of these delays, the program's low-rate initial production decision has been moved from June 2016 to February 2017–an eight month delay since our last assessment. Delays to this production decision resulted in a program deviation report which was reviewed by the Under Secretary of Defense for Acquisition, Technology, and Logistics, who approved the schedule extension and decided not to require the program to establish a new acquisition program baseline until the CH-53K's low-rate production decision is reached. According to program officials, the expected date for the production decision is February 2017. The current acquisition program baseline will remain unchanged until the production decision occurs.

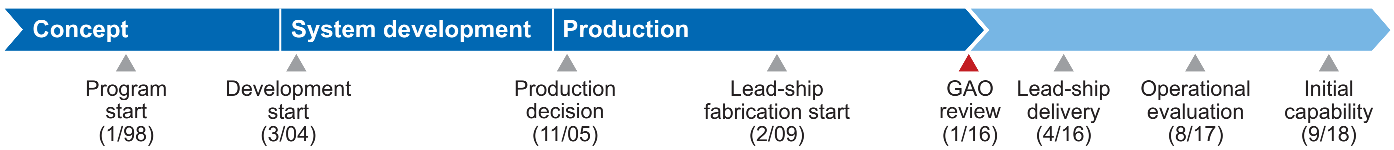
Program Office Comments

The program office provided technical comments, which were incorporated as appropriate.

DDG 1000 Zumwalt Class Destroyer (DDG 1000)

The Navy's DDG 1000 destroyer is a multimission surface ship designed to provide advanced capability for littoral operations and land-attack in support of forces ashore. The ship will feature an integrated power system, a total ship computing environment, and an advanced gun system. Lead ship delivery–comprised of the ship's hull, mechanical, and electrical systems–is expected April 2016, an 18-month delay. Construction is underway on the remaining two ships in the class.

Source: General Dynamics - Bath Iron Works.



Program Essentials

Prime contractor: BAE Systems, Bath Iron Works
Program office: Washington, DC
Funding needed to complete:
- R&D: $133.3 million
- Procurement: $847.2 million
- Total funding: $980.4 million
- Procurement quantity: 0

Program Performance (fiscal year 2016 dollars in millions)

	As of 01/1998	Latest 12/2014	Percent change
Research and development cost	$2,444.3	$10,751.6	339.9%
Procurement cost	$34,896.9	$12,314.5	-64.7%
Total program cost	$37,341.1	$23,066.1	-38.2%
Program unit cost	$1,166.91	$7,688.712	559.9%
Total quantities	32	3	-90.6%
Acquisition cycle time (months)	128	248	93.8%

The DDG 1000 program experienced significant challenges with activating and testing the lead ship's hull, mechanical, and electrical systems resulting in delays to lead ship delivery. These delays could also affect the start of mission system activation and verification that the ship can meet performance requirements. Delivery of the lead ship's hull, mechanical, and electrical systems is now expected in April 2016, an 18-month delay. Program officials said delays were initially driven by production challenges, particularly a shortage of labor to complete electrical work. The program also encountered significant technical issues related to the integrated power system, a critical technology, but the program believes that the system was successfully demonstrated during initial sea trials in December 2015.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
Demonstrate all critical technologies in a relevant environment	●
Demonstrate all critical technologies in an operational environment	○
Complete preliminary design review	●
Product design is stable	
Complete three-dimensional product model	●
Test a system-level integrated prototype	
Manufacturing processes are mature	
Demonstrate critical processes are in control	
Demonstrate critical processes on a pilot production line	
Test a production-representative prototype	

● Knowledge attained
○ Knowledge not attained
.... Information not available
Not applicable

DDG 1000 Program

Technology Maturity

While 3 of the DDG 1000's 11 critical technologies are fully mature, the remaining 8 will not be demonstrated in a realistic environment until testing aboard the lead ship. Reliability of the ship's power conversion and distribution system–a key element of the integrated power system–was the top technical risk for completion of the sea trials required prior to delivery. The program believes that the integrated power system was successfully demonstrated during initial sea trials in December 2015. Issues with the power conversion and distribution system were due, in part, to the Navy's decision to not fully test and validate the performance of the system in a representative environment prior to installation on the ship. The Navy conducted land-based testing of the integrated power system with a configuration representing only half of the system, with plans to install the test equipment on DDG 1002, which it believed was the cost effective approach to risk reduction. As a result, the Navy reported that numerous issues with the power conversion and distribution system were discovered during land-based testing but not resolved before ship installation. Because land-based testing did not include testing to replicate shipboard power loads, power disturbances were discovered during shipboard testing.

The program reported that all mission system equipment for the first two ships has been delivered and installed, with mission system activation planned after lead ship delivery. The contract for the third ship's mission system equipment was awarded in December 2015. Testing of modifications to the multifunction radar to include a volume search capability is ongoing. Multiple tracking exercises with the multifunction radar were conducted at Wallops Island in 2015. A follow-on tracking exercise is planned in June 2016. According to program officials, software acceptance testing for the eighth and final software build for the total ship computing environment has been completed and will be accepted in January 2016. Low-rate initial production decision on the long range land attack projectile is planned for second quarter fiscal year 2016.

Design and Production Maturity

The DDG 1000 design is mature, but ongoing development and shipboard testing of technologies may result in design changes. As of December 2015, the program reported that construction of the three ships in the class was 98, 84, and 43 percent complete, respectively. Program officials said delays to lead ship delivery were initially driven by challenges in completing electrical work, with the shipbuilder citing resource shortages and workforce turnover. Significant technical issues with activation and testing of the lead ship's hull, mechanical, and electrical systems have further delayed lead ship delivery. As of December 2015, the program reported that activation of the lead ship's hull, mechanical and electrical systems was 83 percent complete. The program also reported that initial sea trials in December 2015 demonstrated several ship systems including small boat operations, anchoring, integrated power system, and auxiliary systems and that primary risk reduction objectives were successfully met. Lead ship delivery is expected in April 2016.

Other Program Issues

Late delivery of the lead ship's hull, mechanical, and electrical systems delayed the start of mission system activation and verification that the ship can meet performance requirements. The current estimate for initial operating capability is September 2018, almost two years later than planned. A revision of the program's acquisition program baseline to account for these schedule delays has not yet been approved.

Program Office Comments

In commenting on a draft of this assessment, the Navy concurred with our findings and provided additional information. The Navy noted that the program has made significant progress in the test and activation phase as several ship systems were demonstrated during initial sea trials in December 2015. The Navy noted that analysis continues and any identified corrective actions will be prioritized to best support the continuing schedule of test and trial events. The Navy added that it continues to focus on delivery of the lead ship's hull, mechanical, and electrical systems; sail away and planning mission systems activation. The Navy also provided technical comments, which were incorporated where appropriate.

Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)

The Navy developed the Ford-class nuclear-powered aircraft carrier to introduce new propulsion, aircraft launch and recovery, and survivability capabilities to the carrier fleet. The Ford-class is the successor to the Nimitz-class aircraft carrier, and its new technologies are intended to create operational efficiencies while enabling a 25 percent increase in operational aircraft flights as compared to legacy carriers. The Navy also expects the new technologies to enable Ford-class carriers to operate with reduced manpower.

Source: U.S. Navy.

Concept | **System development** | **Production**

- Program start (6/00)
- Construction preparation contract award (5/04)
- Production decision (7/07)
- Detail design and construction contract award (9/08)
- Second ship contract award (6/15)
- GAO review (1/16)
- Lead-ship delivery (5/16)
- Initial capability (3/17)
- Start operational testing (9/17)

Program Essentials

Prime contractor: Huntington Ingalls Industries
Program office: Washington, DC
Funding needed to complete:
R&D: $378.1 million
Procurement: $14,310.7 million
Total funding: $14,772.3 million
Procurement quantity: 1

Program Performance (fiscal year 2016 dollars in millions)

	As of 04/2004	Latest 07/2015	Percent change
Research and development cost	$5,154.0	$5,059.1	-1.8%
Procurement cost	$33,017.6	$31,339.1	-5.1%
Total program cost	$38,171.6	$36,547.9	-4.3%
Program unit cost	$12,723.855	$12,182.648	-4.3%
Total quantities	3	3	0.0%
Acquisition cycle time (months)	137	155	13.1%

The Navy reported 9 of CVN 78's 13 critical technologies as mature, though testing of immature technologies continues to reveal issues and ship delivery is delayed. CVN 78 is over 95 percent complete, but to manage risks the Navy deferred some work until after ship delivery. This could obscure costs and result in delivery of an incomplete ship. Lead ship procurement costs grew by almost 23 percent from $10.5 billion to $12.9 billion–the limit of the current legislated cost cap. The National Defense Authorization Act for Fiscal Year 2016 reduced the CVN 79 cost cap to $11.4 billion. The Navy adopted a two-phased acquisition approach for CVN 79 and deferred installation of some upgrades; however, this strategy will delay some construction and costs to after ship delivery.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• Complete three-dimensional product model	●
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

CVN 78 Program

Technology and Design Maturity

The Navy reported that 9 of CVN 78's 13 critical technologies are mature, though testing of immature technologies continues to reveal issues. The Navy began deadload testing of the electromagnetic aircraft launch system (EMALS) from the ship's deck but halted testing in 2015 due to a system component failure. The Navy plans to begin testing EMALS and the advanced arresting gear (AAG) on board CVN 78 with aircraft in 2016. AAG began shipboard testing in July 2015, with projected completion after CVN 78 delivers. The dual band radar (DBR) also began shipboard testing this year, despite problems land-based testing revealed that could affect the radar's air traffic control functionality. Both AAG and DBR are still engaged in land-based testing. The Navy will replace DBR on CVNs 79 and 80 with the Enterprise Air Surveillance Radar suite, but has not yet awarded a contract to develop the new radar. If the new radar cannot fit within the existing design, CVNs 79 and 80, which use the CVN 78 design, would require design modifications.

Production Maturity

CVN 78 is over 95 percent complete and scheduled to deliver in May 2016, at the earliest, about 6 to 8 weeks later than planned due to delayed sea trials. To manage remaining risks, the Navy deferred some work until after ship delivery, a decision that could obscure costs and result in delivery of an incomplete ship. Construction continues on CVN 79, which is 14 percent complete. The Navy awarded the detail design and construction contract for this ship in June 2015. In February 2015, the Navy also requested the first year of advance procurement funding for CVN 80.

Other Program Issues

In 2007, Congress established a procurement cost cap of $10.5 billion for CVN 78 and since then, lead ship procurement costs increased by almost 23 percent to the current statutory cost cap of $12.9 billion. The National Defense Authorization Act (NDAA) for Fiscal Year 2016 reduced the cap for CVN 79 to $11.4 billion, though costs for this ship may also increase. The Office of the Secretary of Defense and the Congressional Budget Office expect CVN 79 to surpass the earlier statutory cost cap of $11.5 billion by at least $235 million. The Navy asserts it will meet CVN 79's cost cap, but assumes unprecedented efficiency gains in construction–that CVN 79's production hours will be 18 percent lower than CVN 78. The Navy also adopted a two-phased acquisition approach for CVN 79 that will shift some construction to a post-delivery period. According to program officials, this will enable the Navy to procure and install electronic systems at the latest possible date to prevent obsolescence prior to ship deployment. However, this strategy results in a less capable and complete ship at delivery. The Navy is also transferring the costs of a number of known capability upgrades from CVN 79 to other accounts by deferring work to future maintenance periods–obscuring CVN 79's actual costs.

In August 2015, the Deputy Secretary of Defense directed the Navy to complete the full ship shock trial on CVN 78, not CVN 79. The NDAA for fiscal year 2016 restricts the obligation or expenditure of fiscal year 2016 funds for CVN 79 until the Navy takes certain steps, including either certifying it will conduct the shock trial on CVN 78 before the ship's first deployment or submitting a notification of the waiver to this requirement.

Program Office Comments

In its comments, the Navy stated that all costs to complete CVN 78 will be included under the $12.9 billion cost cap. In 2013, the Navy deferred some non-critical work to a post-delivery period to allow the shipbuilder to focus on the completion of new technologies and other critical work to deliver the ship in the most cost effective manner. All work will be completed under the cost cap prior to the start of Initial Operational Testing and Evaluation. The Navy noted that the statement for CVN 79, "this strategy will delay some construction and costs to after ship delivery", is incorrect. The Navy will deliver a complete and deployable ship at the end of Phase II construction.

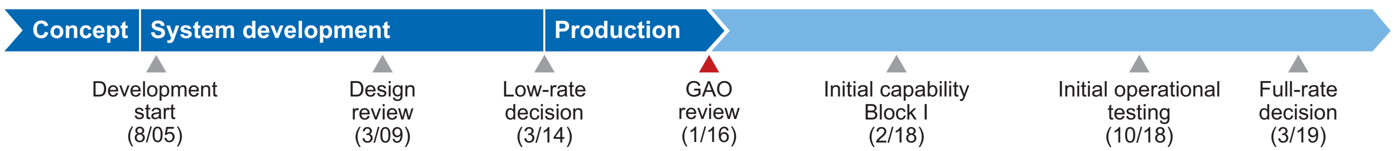
GAO Response

As we reported in October 2015, CVN 78 must complete its final, more complex, construction phase concurrent with key test events, with no margin for the unexpected. Additional costs are likely. The Navy believes that our statement regarding CVN 79's capability at ship delivery is incorrect. However, as the Navy states in its comments, the ship will not be fully complete and deployable at delivery (known as Phase I) in fiscal year 2022, but rather much later–in fiscal year 2025 at the end of Phase II construction.

Ground/Air Task Oriented Radar (G/ATOR)

The Marine Corps' Ground/Air Task Oriented Radar (G/ATOR) is an active electronic scanned array, three-dimensional, short-to-medium range, multi-role radar designed to detect, identify, and track threats such as cruise missiles, rockets, and artillery. It will replace five radars. It is being acquired in blocks; later blocks are mostly software upgrades. GAO assessed Block 1, which has an air defense and surveillance role, and made observations on Block 2, which will determine enemy firing positions and point of impact for incoming fire.

Source: U.S. Marine Corps.



Program Essentials

Prime contractor: Northrop Grumman
Program office: Quantico, VA
Funding needed to complete:
- R&D: $238.7 million
- Procurement: $1,445.8 million
- Total funding: $1,688.2 million
- Procurement quantity: 39

Program Performance (fiscal year 2016 dollars in millions)

	As of 08/2005	Latest 07/2015	Percent change
Research and development cost	$379.9	$1,048.6	176.0%
Procurement cost	$1,192.8	$1,723.1	44.5%
Total program cost	$1,572.7	$2,775.4	76.5%
Program unit cost	$24.573	$61.676	151.0%
Total quantities	64	45	-29.7%
Acquisition cycle time (months)	66	138	109.1%

The cost data includes G/ATOR Blocks 1 and 2. The acquisition cycle time was calculated for Block 1 only.

The G/ATOR program received approval to enter production in March 2014 with mature technologies, a design refined for production, and production processes that had been demonstrated, but were not in control. In early testing, software stability was a major reliability driver. In October 2014, an expert panel found G/ATOR's reliability requirements did not reflect operational needs and recommended changes. In March 2015, the Marine Corps revised the reliability requirements. The program continues to address software issues during testing. Program officials noted G/ATOR will transition to a new semiconductor technology in 2016, which will be used in initial operational testing. A revised test plan capturing the new technology and reliability requirements is under final review by the Navy.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	○
• Demonstrate critical processes on a pilot production line	●
• Test a production-representative prototype	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

G/ATOR Program

Technology and Design Maturity

As of July 2015, G/ATOR reported that all six of its critical technologies are fully mature, and that the design had been refined for production. The program's design was stable at critical design review in 2009, but the number of total estimated drawings has increased as the program developed more detailed drawings to facilitate production. As of July 2015, 97 percent of the refined sets of drawings have been released. While G/ATOR hardware has proven to be reliable, the program has experienced software maturity and quality problems, which have affected the reliability of the overall system. In June 2014, the Navy convened a panel of experts that conducted an in-depth analysis of the program, after it failed to meet its reliability target during developmental testing. The panel found G/ATOR's reliability requirement was likely unachievable and did not reflect operational needs. In response, in March 2015, the Marine Corps clarified the requirement to ensure it was consistent with the G/ATOR's operational mission profile. According to the program manager, the program continues to make software updates to address quality and reliability issues.

The program plans to upgrade the radar's transmit and receive modules by using a newer semiconductor technology starting with radars produced in 2016. According to program officials, this new gallium nitride technology is mature and the fit of the new modules will be the same as the older gallium arsenide modules, which minimizes design changes. The gallium nitride technology is expected to achieve better performance with higher reliability at a lower cost by reducing the number of modules required.

Production Maturity

The G/ATOR program received approval to enter low-rate production in March 2014 with production processes that had been demonstrated on a production line, but were not demonstrated as in control. While the program's manufacturing readiness reached the level recommended by DOD guidance, it did not reach the level of control called for in GAO's best practices. This status is unchanged.

In April 2015, the program office received approval to increase initial production quantities from 8 to 14 radar systems. The program office confirmed that of the 14 initial production radar systems, the first six will use the older gallium arsenide modules and the later eight will use the newer gallium nitride modules. According to the program office, delivery of the first production radar with the older module technology is expected in early 2017.

Other Program Issues

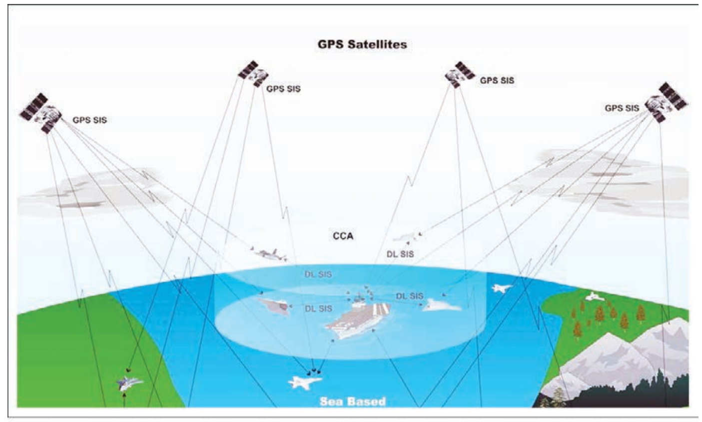
The G/ATOR program is in the process of revising its test strategy to address reliability concerns raised by an expert panel, to include a test strategy for gallium nitride, and clarify the operational reliability requirements. The program originally planned to conduct operational testing with the gallium arsenide configuration, but DOD's Director, Operational Test and Evaluation raised concerns about the production representativeness of this configuration as a majority of the planned G/ATOR procurements are with the newer gallium nitride modules. Program officials said testing using gallium nitride will occur in 2018. A revised test plan capturing the new technology and reliability requirements has been coordinated with stakeholders, including DOD test officials, and is under final review by the Navy.

Program Office Comments

In commenting on a draft of this assessment, the program office noted that the G/ATOR program has remained on schedule and decreased the estimated total program cost by more than15 percent since the program was rebaselined in 2010. It also noted that 15 months into the initial low-rate production contract awarded in October 2014 for Block 1, the program remains on schedule demonstrating that production processes are in control. The program office noted that transition to the newer gallium nitride semiconductor technology in 2016 is also on schedule. It noted that the Block 2 software contract was awarded in August 2015, and that the program continues to refine the quality of the system software to be used in initial low-rate production hardware deliveries in 2017. Technical comments were provided by the program office, which were incorporated where deemed appropriate.

Joint Precision Approach and Landing System Increment 1A (JPALS Inc 1A)

JPALS Increment 1A is a Navy-led program to develop a GPS-based landing system for aircraft carriers and amphibious assault ships to support operations with the Joint Strike Fighter and Unmanned Carrier-Launched Airborne Surveillance and Strike System. The program intends to provide reliable precision approach and landing capability in adverse environmental conditions. We assessed increment 1A. As a result of restructuring, previously planned additional increments are no longer part of the program.



Source: U.S. Navy.

Concept | **System development** | **Production**

- Development start (7/08)
- GAO review (1/16)
- Restructured development start (6/16)
- Restructured design review (2/17)
- Restructured low-rate decision (3/19)
- Initial capability (9/20)

Program Essentials

Prime contractor: Raytheon
Program office: Lexington Park, MD
Funding needed to complete:
R&D: $188.9 million
Procurement: $476.8 million
Total funding: $665.7 million
Procurement quantity: 17

Program Performance (fiscal year 2016 dollars in millions)

	As of 07/2008	Latest 07/2015	Percent change
Research and development cost	$849.8	$1,106.3	30.2%
Procurement cost	$228.8	$476.8	108.4%
Total program cost	$1,086.0	$1,590.5	46.5%
Program unit cost	$29.352	$58.908	100.7%
Total quantities	37	27	-27.0%
Acquisition cycle time (months)	75	146	94.7%

JPALS Increment 1A began development in July 2008. Both of the program's previously identified critical technologies were demonstrated in a realistic environment during sea-based flight testing in 2013. Due to affordability concerns and other military and civilian plans for similar landing systems, the Navy changed the program in 2014 to accelerate auto-landing capabilities and eliminate other capabilities. Doing so reduced planned quantities while increasing development costs and resulted in a critical Nunn-McCurdy unit cost breach. As a result, the program is restructuring and development will restart in June 2016. The program is currently conducting new system-level reviews, developing software and a new cost and schedule baseline, and will reassess technology and design maturity.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	....
• Demonstrate all critical technologies in an operational environment	....
• Complete preliminary design review	○
Product design is stable	
• Release at least 90 percent of design drawings	....
• Test a system-level integrated prototype	○
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
.... Information not available
Not applicable

JPALS Inc 1A Program

Technology, Design, and Production Maturity

In June 2014, the JPALS program was changed to accelerate the development of aircraft auto-land capabilities. The program's technology and design maturity will need to be reassessed to account for this change. The program reported conducting a system requirements review in March 2015, and plans to conduct a system-level preliminary design review in February 2016. This will be done in advance of the development restart for the restructured program, scheduled for June 2016. JPALS Increment 1A's functionality is primarily software-based and the changes require additional software development. The planned completion of the software development efforts necessary to achieve baseline capabilities has not yet been determined. The current number of total drawings expected for the restructured program also has not yet been determined. Program officials stated that the Navy conducted an affordability analysis in June 2015, and also stated that they are refining cost and schedule estimates. They noted that the requisite mandatory program certifications will be completed prior to the restructured development restart. The program then plans to restart system-level developmental testing in fiscal year 2017.

Prior to this restructuring, the program had completed a number of activities to mature its technology and design. JPALS Increment 1A began its original development in July 2008, held a critical design review in December 2010, and released all of its expected design drawings at that time. The program began testing a system-level prototype in July 2012. Testing of the system in its prior configuration began in December 2012. The program demonstrated its two identified critical technologies in a realistic environment through sea-based flight testing and completed 70 ship-based auto-landing approaches using legacy aircraft as of November 2013. According to JPALS officials, the Increment 1A program did not identify any critical manufacturing processes due to the system's hardware being comprised primarily of off-the-shelf components. The program accepted delivery of eight engineering development models, seven of which were considered production-representative.

Other Program Issues

In 2013, the Navy conducted a review of its precision approach and landing capabilities to address budget constraints and affordability concerns. In light of these concerns, as well as other military service and civilian plans to continue use of current landing systems, the Navy restructured the JPALS program. The program was reduced from seven increments to one intended to support the Joint Strike Fighter and Unmanned Carrier-Launched Airborne Surveillance and Strike System. The Navy also accelerated the integration of auto-land capabilities originally intended for the future increments, and eliminated both the integration of JPALS with other sea-based legacy aircraft and the land-based version of the system. These changes increased the development funding required for auto-land capabilities and reduced system quantities, resulting in unit cost growth and a critical Nunn-McCurdy unit cost breach reported in March 2014. The Under Secretary of Defense for Acquisition, Technology, and Logistics certified the restructured program and directed the Navy to continue risk reduction efforts to incorporate the auto-land capabilities.

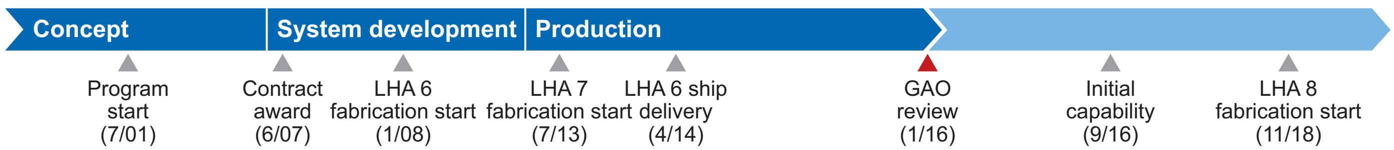
Program Office Comments

In commenting on a draft of this assessment, the program office noted that JPALS is no longer an incremental program and has completed the certification process triggered by the Nunn McCurdy breach. The requirements originally associated with JPALS Increments 1A (ship's system), 3 (manned auto-land capability) and 4 (unmanned auto-land capability) have been combined into a single program. While the Navy continues JPALS auto-land development to support manned and unmanned aircraft, the engineering development models developed and built under the original JPALS Increment 1A program are being utilized to support Joint Strike Fighter test and operational support requirements.

LHA 6 America Class Amphibious Assault Ship (LHA 6)

The Navy's LHA 6 class will replace the LHA 1 Tarawa-class amphibious assault ships. The LHA 6 class is based on the fielded LHD 8 and consists of three ships. The ships feature enhanced aviation capabilities and are designed to support Marine Corps assets in an expeditionary strike group. LHA 6 construction began in December 2008 with delivery in April 2014. LHA 7 construction began in July 2013 and delivery is expected in December 2018. The Navy intends to use limited competition to award a contract for LHA 8 in fiscal year 2016.

Source: Navy photo by Mass Communication Specialist 1st Class Michael McNabb.



Program Essentials

Prime contractor: Huntington Ingalls Industries
Program office: Washington, DC
Funding needed to complete:
- R&D: $38.3 million
- Procurement: $3,221.7 million
- Total funding: $3,261.2 million
- Procurement quantity: 1

Program Performance (fiscal year 2016 dollars in millions)

	As of 01/2006	Latest 07/2015	Percent change
Research and development cost	$237.0	$446.6	88.4%
Procurement cost	$3,175.0	$9,521.6	199.9%
Total program cost	$3,412.1	$9,970.6	192.2%
Program unit cost	$3,412.072	$3,323.531	-2.6%
Total quantities	1	3	200.0%
Acquisition cycle time (months)	146	182	24.7%

LHA 6 began construction in December 2008 with mature technologies but an incomplete design. The ship delivered in April 2014 after a 20 month delay and has begun post-delivery activities, including the post shakedown availability which was delayed until May 2015. The program extended the duration of this activity through February 2016 to test modifications made to the flight deck of the ship so that it can accommodate the F-35. LHA 7–which largely shares the LHA 6 design–began construction in July 2013. Changes to LHA 8 are more significant and include the addition of a well deck. The program is working with two shipyards and intends to competitively award a contract to one of them in fiscal year 2016.

Attainment of Product Knowledge

As of January 2016

Knowledge point	Status
Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• *Complete three-dimensional product model*	
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

LHA 6 Program

Technology, Design, and Production Maturity

When the program awarded the LHA 6 construction contract in June 2007, it considered all LHA critical technologies, plus six additional non-critical subsystems necessary to achieve capabilities, as mature. The Joint Precision Approach and Landing System, a subsystem, was restructured to focus on aircraft auto-land capabilities, and it is uncertain when the system will be ready for installation. In the interim, the program will use backup aviation control systems to meet requirements.

LHA 6, the lead ship, was delivered to the Navy in April 2014, 20 months later than the contracted delivery date. The program plans to integrate 17 additional design changes to accommodate the F-35. These changes are estimated to cost about $57 million.

Construction of LHA 7–which modifies the LHA 6 design–began in July 2013, and over 30 percent of the ship has been built as of July 2015. The program anticipates the ship's delivery will be delayed by about six months to December 2018 due to the design changes required for operations with the F-35. Although the program claims the shipbuilder has improved its performance by implementing lessons learned and re-hiring staff from the LHA 6 construction, the contractor is currently not achieving the necessary labor efficiency rates and is reporting increasing costs. The Navy has provided incentives specific to the shipbuilder to promote better quality.

Design changes on LHA 8 will be more significant as the Navy is incorporating a well deck that accommodates two landing craft, and work is underway to design the ship to reduce the ship's acquisition and lifecycle costs. The Navy is working with the two shipyards that it determined capable of building the ship without major recapitalization to assist with this effort.

Other Program Issues

LHA 6's delivery was 20 months later than initially planned, which delayed the start of operational testing 10 months to April 2015. In order to create cost savings by combining operational testing with a pre-deployment fleet exercise, the end of operational testing was extended by 9 months to June 2017. In order to make modifications to accommodate the F-35s, the Navy recently extended a planned maintenance period used to complete work and correct defects. The Navy currently plans to declare the ship operational in September 2016. This would mean the Navy plans to declare the ship operational nearly a year before operational testing is complete.

In January 2015, the Director, Operational Testing and Evaluation expressed concern that the LHA 6's defense system will not be able to defend against all anti-ship cruise missile threats. The program initially disagreed, but believes it has taken some actions to address these concerns.

The Navy issued a combined solicitation to award separate contracts for the detail, design and construction of the LHA 8, six TAO(X) oiler ships, and contract design support for the LX(R) program. Currently the Navy plans to conduct a limited competition between two shipbuilders and award the LHA 8 to one competitor, the TAO(X) to a second competitor, and portions of the LX(R) contracts to each competitor. Navy officials believe that this strategy will both support the industrial base to maintain competition for future projects, and lower prices.

Program Office Comments

LHA 6 was successfully delivered with no fit and finish concerns and no starred trial cards, outstanding for a first of class large deck amphibious ship, and is designed and built to meet its validated performance characteristics. Recently, LHA 6 completed a two-month operational deployment with Marine Corps, expeditionary strike group staff, and aircraft. During the post shakedown availability, LHA 6 is receiving modifications to fully integrate ship capability in support of F-35B operations in preparation for operational deployment. Declaration of LHA 6's initial operational capability is planned for September 2016 per the LHA capability development document.Construction of LHA 7 is not experiencing labor resource issues as seen in the past and the shipbuilder continues to drive a positive schedule variance for the program. According to the program, labor efficiency concerns are being addressed by the shipbuilder and contract incentives have worked to improve construction quality.

Littoral Combat Ship (LCS)

The Navy's Littoral Combat Ship (LCS) is designed to perform mine countermeasures, antisubmarine warfare, and surface warfare missions. It consists of the ship itself, or seaframe, and the mission package it deploys. The Navy is buying two designs of LCS–the Freedom variant, a steel monohull (LCS 1 and odd numbered ships) and the Independence variant, an aluminum trimaran hull (LCS 2 and even numbered ships)–and has awarded contracts for 26 seaframes. We assessed both seaframe designs.

Source: Lockheed Martin (left); General Dynamics (right).

Concept | **System development** | **Production**

- Development start (5/04)
- Production decision (12/04 & 10/05)
- Lead-ship delivery (9/08 & 12/09)
- Initial capability LCS1 (3/13)
- Start operational test - LCS1 (4/14)
- Start operational test - LCS2 (8/15)
- Initial capability LCS2 (12/15)
- GAO review (1/16)

Program Essentials

Prime contractor: Austal USA, Lockheed Martin
Program office: Washington Navy Yard, DC
Funding needed to complete:
R&D: $323.9 million
Procurement: $6,505.7 million
Total funding: $6,966.8 million
Procurement quantity: 9

Program Performance (fiscal year 2016 dollars in millions)

	As of 05/2004	Latest 08/2015	Percent change
Research and development cost	$951.61	$3,464.5	264.1%
Procurement cost	$505.97	$17,253.4	3,310.0%
Total program cost	$1,457.58	$20,953.5	1,337.6%
Program unit cost	$364.396	$654.797	79.7%
Total quantities	4	32	700.0%
Acquisition cycle time (months)	41	119	190.2%

Cost data are for the seaframe program only. Research and development funding includes detail design and construction of two ships.

The LCS seaframe program has demonstrated the maturity of 16 of its 18 critical technologies and has accepted delivery of six seaframes. The Navy recently downgraded the maturity assessments of two critical technologies, identified critical deficiencies during acceptance testing, and continues to incorporate changes into follow-on ship designs. In March 2015, contract modifications changed the delivery dates of LCS 5 through 24 by up to a year or more, and added priced options for the procurement of LCS 25 and 26 and special incentives. The Navy plans to procure a future small surface combatant–referred to as a frigate–based on a modified LCS design starting in fiscal year 2019.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●

Product design is stable	
• Complete three-dimensional product model	●
• *Test a system-level integrated prototype*	

Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

LCS Program

Technology Maturity

Sixteen of the 18 critical technologies, the total number of technologies for both designs, are mature and have been demonstrated in a realistic environment. The Navy downgraded the maturity of two Independence variant technologies–the aluminum structure and the launch, handling and recovery system planned for use on this variant after LCS 4. The Navy reported that the results of survivability and seaframe operational testing will validate the maturity of the aluminum structure. The Navy changed the vendor for the launch, handling, and recovery system on LCS 6, according to the program office, and certification testing is incomplete. At LCS 6's acceptance trials, the Navy reported this system resulted in one of the 8 critical deficiencies identified. The Chief of Naval Operations approved delivery of the ship in August 2015 based on a plan to correct these deficiencies. The Navy also accepted LCS 5, a Freedom variant, following trials in September 2015. Both LCS 5 and 6 will undergo full ship shock trials in summer 2016 and a survivability trial for the Independence variant is scheduled for January 2016. The Navy formally declared the Independence variant as capable of initial operations in December 2015.

Design and Production Maturity

To date, the Navy has accepted delivery of six seaframes: LCS 7 through LCS 20 are in various stages of construction; and LCS 21 through 26 are now under contract. In March 2015, the Navy modified the block buy contracts for LCS 5 through 24 to add priced options for the procurement of LCS 25 and 26, approved delays in LCS delivery schedules by up to a year or more, and added new incentives totaling up to $45 million to each yard for launch and delivery. The Navy continues to incorporate changes into follow-on ships, including updated radars starting on LCS 17 and an over-the-horizon surface-to-surface missile. The program has also undertaken efforts to reduce weight including removal of the fin stabilizer system from the Freedom variant (LCS 9 and following) and reducing fuel on the Independence variant (LCS 4 and following).

Other Program Issues

In February 2014, the office of the Secretary of Defense directed the Navy to contract for no more than 32 LCS, citing concerns about the ship's survivability and lethality. In December 2014, the same office accepted the Navy's recommendation to procure a modified LCS–which the Navy is calling a frigate–for the final 20 ships of its 52 small surface combatants requirement. The frigate is expected to have some improved lethality and survivability capabilities, including an over-the-horizon missile and improved sensors, though the improvements will not offer as robust a capability as other options considered by the Navy. The Navy is concurrently developing requirements, design, final acquisition strategy, and a service cost position. The feasibility of upgrades will depend on continuing weight reduction initiatives undertaken by the LCS program and shipbuilders. Delays in the delivery of LCS may impact the feasibility of the Navy's plan to start frigate production at the LCS shipyards in fiscal year 2019. In December 2015, the Secretary of Defense directed the Navy to decrease the quantity of seaframes to 40. The program office is in the process of responding to this direction.

Program Office Comments

In addition to providing technical comments, the program office noted that, as of December 2015, both LCS variants have achieved initial operational capability. According to Navy officials, the design is stable, meets all approved requirements, and is in full serial production at both shipyards. With the delivery of LCS 5 and 6, each shipyard will deliver an LCS, on average, every six months for the remainder of the block buy. LCS 5 and 6 delivered with the fewest trial cards, or issues that require correction, for each variant to date. The Navy continues to validate modeling and simulation through testing. Fiscal year 2016 planned test events of note include: multi-compartment surrogate events; full ship shock trials; and launch, handling, and recovery system certification. The Navy has assessed cost, schedule, and technical feasibility of forward-fit frigate lethality/survivability enhancements on the Flight 0+ ships and developed plans for incorporation as early as fiscal year 2016, given the appropriate funding.

Littoral Combat Ship - Mission Modules (LCS Packages)

The Littoral Combat Ship (LCS) will provide mine countermeasures (MCM), surface warfare (SUW), and antisubmarine warfare (ASW) capability using mission packages. Packages include weapons and sensors launched and recovered from LCS seaframes. The Navy plans to deliver capability incrementally and has set interim requirements that are below the baseline requirements for some increments. We assessed mission packages progress against the threshold requirements that define the baseline capabilities currently expected for each package.

Source: U.S. Navy.

Concept | **System development/Production**

- First MCM delivery (9/07)
- First SUW delivery (7/08)
- DOD program review (7/13)
- First ASW delivery (9/14)
- Initial capability SUW (11/14)
- GAO review (1/16)
- Initial capability ASW (9/17)
- Initial capability MCM (TBD)

Program Essentials

Prime contractor: Northrop Grumman Systems Corporation
Program office: Washington Navy Yard, DC
Funding needed to complete:
R&D: $657.3 million
Procurement: $3,763.4 million
Total funding: $4,452.9 million
Procurement quantity: 49

Program Performance (fiscal year 2016 dollars in millions)

	As of 08/2007	Latest 09/2015	Percent change
Research and development cost	N/A	$2,520.4	N/A
Procurement cost	$3,496.8	$4,377.3	25.2%
Total program cost	N/A	$6,930.0	N/A
Program unit cost	N/A	$108.282	N/A
Total quantities	64	64	0.0%
Acquisition cycle time (months)	N/A	N/A	N/A

The current estimate does not include $3.6 billion of procurement funding for life cycle replacement and modernization of mission systems.

The Navy has accepted delivery of 13 mission packages prior to demonstrating that they meet threshold capability requirements (threshold requirements) on both seaframes. The MCM package recently completed a series of development tests on the first increment of capability, but reliability issues have led the Navy to suspend further testing. The current increment of the SUW package met its interim requirements on one seaframe and is in testing on the other. The Navy is modifying an Army missile to provide capabilities to meet threshold requirements for SUW. The ASW package has been delayed by a year as funding was moved from ASW to MCM. The Navy is developing, testing, and integrating the sub-systems needed to meet threshold requirements for each mission package on both seaframe variants and is not expected to field a set of mission packages that meet these requirements until 2019.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	○
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• *Release at least 90 percent of design drawings*	
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

LCS Packages Program

Mine Countermeasures (MCM)

The Navy has accepted six MCM packages without demonstrating that they meet interim or threshold requirements. The package has four increments: the first is designed to remove sailors from the minefield and improve mine detection, classification, and neutralization over legacy vessels. Operational testing for the first increment was scheduled to begin in fiscal 2015. This testing has been suspended following a series of performance and reliability shortfalls during developmental tests. The Navy stated that, when the package was available, it significantly exceeded performance requirements during tests. The Department of Operational Test and Evaluation stated that the Navy did not take into account that the systems were unavailable for 85 of 132 days of testing. Test officials determined that the current MCM system would not be found operationally effective and critical MCM systems and the Independence-variant seaframe are not reliable. Test officials support the Navy's September 2015 decision to suspend further testing and evaluate alternatives to key systems and assess technical and programmatic risks. The findings of this evaluation have not yet been finalized.

Surface Warfare (SUW)

The Navy has accepted seven SUW packages and plans to accept one more in fiscal 2017. Each increment one package currently consists of two 30 millimeter guns, an armed helicopter, and two rigid hull inflatable boats. In August 2014, the Navy found that the package met interim performance requirements on the Freedom variant and is currently testing the package on the Independence variant. To meet threshold requirements for SUW a surface-to-surface missile is required. The Navy plans to use the Army's Longbow HELLFIRE missile for this capability, as it canceled two previous efforts. According to program officials, initial demonstrations with Longbow HELLFIRE have been successful and operational testing is planned for fiscal year 2017.

Antisubmarine Warfare (ASW)

According to the Navy, the systems that comprise the ASW mission package are mature, as they have been fielded by United States and foreign navies. In September 2014, the Navy completed development testing aboard the Freedom variant, but the mission package is currently 5 tons over its weight parameters. Navy program officials stated that they recently awarded contracts to reduce package weight by at least 15 percent. The Navy is now planning to meet the threshold requirement for ASW in 2017, a one year delay from last year's estimate, as the Navy redirected funding for ASW to make up for funding shortfalls in the MCM and SUW packages.

Other Program Issues

The Navy continues to procure LCS seaframes, even though the sub-systems necessary to meet threshold mission package requirements have not yet been fully developed and integrated with both seaframe designs. The Navy will not achieve the capability to meet threshold requirements for all three of the mission packages until 2019, by which time it plans to take delivery of 22 ships. The Navy plans to begin procurement of a modified LCS in 2019.

Program Office Comments

The Navy stated that it is purchasing the quantity of mission systems and packages needed for system integration, crew training, developmental testing, operational testing, and LCS deployments. The packages have all been demonstrated in a relevant environment prior to integration. The Navy is purchasing the systems in accordance with DOD regulations. The Navy is following its plan to incrementally deliver operationally effective mission package capability to the fleet rather than waiting years to acquire all mission systems needed to meet minimum requirements. For example, initial SUW capability has been fielded as planned. Full SUW and ASW capability will be fielded in fiscal 2017. The program office provided technical comments, which were incorporated as appropriate.

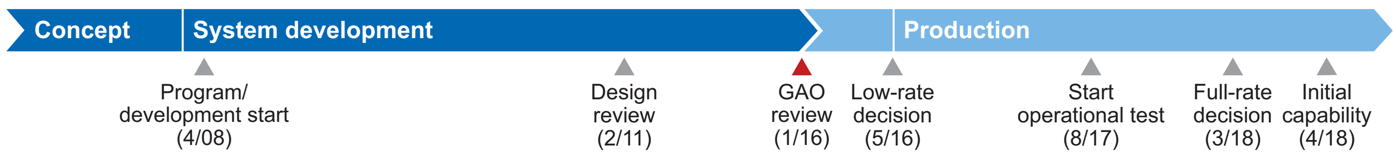
GAO Response

The systems that comprise the Navy's mission packages have yet to work together to achieve stated minimum requirements. The failures of the MCM package during testing this year and the subsequent indefinite delay of MCM initial capability are emblematic of the Navy's challenges. In the absence of a defined increment-based approach to sequentially gain knowledge and meet requirements, the Navy's acquisition approach is not in accordance with best practices.

MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)

The Navy's MQ-4C Triton is intended to provide persistent maritime intelligence, surveillance, and reconnaissance (ISR) data collection and dissemination capability. Triton is planned to be an unmanned aircraft system operated from five land-based sites worldwide as part of a family of maritime patrol and reconnaissance systems. Based on the Air Force's RQ-4B Global Hawk air vehicle, Triton is part of the Navy's plan to recapitalize its airborne ISR assets by the end of the decade.

Source: Courtesy Northrop Grumman/Robert Brown.



Program Essentials

Prime contractor: Northrop Grumman Systems Corporation
Program office: Patuxent River, MD
Funding needed to complete:
- R&D: $228.4 million
- Procurement: $8,497.1 million
- Total funding: $8,866.7 million
- Procurement quantity: 66

Program Performance (fiscal year 2016 dollars in millions)

	As of 02/2009	Latest 12/2014	Percent change
Research and development cost	$3,370.5	$3,950.7	17.2%
Procurement cost	$10,002.5	$8,563.9	-14.4%
Total program cost	$13,783.4	$12,814.6	-7.0%
Program unit cost	$196.906	$183.066	-7.0%
Total quantities	70	70	0.0%
Acquisition cycle time (months)	92	120	30.4%

The Triton is projected to enter production in May 2016 with its one critical technology mature, its design stable, and critical manufacturing processes demonstrated on a pilot production line. The maturity of some manufacturing processes, however, is below the level recommended by best practices. There have been quality and schedule delays with the manufacturing of Triton's wings for test aircraft, and the desired manufacturing process maturity level for the wings will not be achieved until after production start. Flight testing is currently behind schedule and fatigue testing has been delayed, resulting in concurrency between development and production where discovering deficiencies may result in costly rework and retrofits. The size and complexity of the aircraft's software continues to increase with less reuse of existing code than originally planned.

Attainment of Product Knowledge

Projected as of January 2016	
Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	○
• Demonstrate critical processes on a pilot production line	●
• Test a production-representative prototype	○

● Knowledge attained
○ Knowledge not attained
.... Information not available
Not applicable

MQ-4C Triton Program

Technology and Design Maturity

The program's only critical technology is now fully mature. According to the Navy, Triton's design was considered stable at the critical design review in 2011, but demonstration of the design maturity through testing with a system-level integrated prototype did not occur until 2012. There was immature technology at program start and no prototype testing at the design review, so the program accepted knowledge deficits. In addition, the number of design drawings have increased by 70 percent since 2011 because drawings releasable at that time did not include drawings for components other than the air vehicle. According to the program, the design is now stable and demonstrated.

Production Maturity

The program held a production readiness review in June 2015 and concluded that the system was ready to proceed to production based on the demonstration of its critical manufacturing processes on a pilot production line and other activities. The review highlighted key areas of remaining work, including assessing the producibility of Triton's wings. Triton wing quality problems have delayed wing delivery for some test aircraft. The program does not expect to bring its wing manufacturing processes under control, as recommended by best practices, until about six months after production start. In addition, the program will not test a fully configured, production representative prototype to demonstrate system functionality and reliability, also recommended by best practices, until October 2016, 5 months after production start.

Other Program Issues

The program previously planned to complete approximately 13,000 flight test points prior to December 2015. As of September 2015, fewer than 5,000 have been completed. Overall, more than 22,000 test points are planned, which means the Navy will be executing the majority of its test points after production start. The Navy also delayed the start of fatigue testing to determine the airframe's long-term durability until two years after production start. The delivery of 18 production aircraft is planned before this testing is complete. Our previous work has shown that concurrency between development testing and production increases the risk of discovering deficiencies that could require costly design changes to systems already produced. The Navy acknowledges that the Triton may face this risk.

The size and complexity of Triton's software continues to increase. The estimated software lines of code needed has increased from 6.6 million to 8.9 million since the start of software development, with the estimated amount of new software increasing from 16 to 26 percent. Generally, the development of new code takes more effort than the reuse or modification of existing code.

Finally, the Navy recently changed Triton's acquisition strategy in June 2015 by combining three separate increments into one acquisition effort. As we reported in December 2014, this is a riskier approach that deviates from best practices. Our previous work has found that evolutionary, incremental approaches facilitate more success in meeting program goals. According to acquisition guidance in place at the time of the Navy's original business case, as well as statute, an incremental approach would have required the Navy to develop and present a business case for each future increment. We recommended in our previous work that the Navy update the existing business case; however, the program has not yet completed this task.

Program Office Comments

In commenting on a draft of the assessment, the program office stated that the MQ-4C Triton program continues to demonstrate success during its system development and demonstration phase as evidenced by successful entry into operational assessment on November 17, 2015. Production readiness reviews have been conducted in preparation for the low-rate initial production decision review in the third quarter of fiscal year 2016. While the program has experienced delays in wing delivery for the two system demonstration test articles, production planning is on schedule for aircraft delivery in support of initial operational test and evaluation. Upon approval of the acquisition strategy on June 15, 2015, the program fully integrated planning for phased capability upgrades. The Triton program benefits from strong support within the Department of the Navy.

MQ-8 (Fire Scout)

The Navy's MQ-8 unmanned aerial vehicle is intended to provide real-time imagery and data in support of intelligence, surveillance, and reconnaissance missions. The MQ-8 system is comprised of one or more air vehicles with sensors, a control station, and ship equipment to aid in launch and recovery. The air vehicle launches and lands vertically, and operates from ships and land. The MQ-8 is intended for use in various operations, including surface, anti-submarine, and mine warfare. We assessed the latest variant, the MQ-8C.

Source: Northrop Grumman Systems Corporation.

Concept | System development | Production

- Program start (1/00)
- Design review (11/05)
- MQ-8C rapid deployment start (4/12)
- MQ-8C first flight (10/13)
- GAO review (1/16)
- Milestone recertification (5/16)
- MQ-8C start operational test (9/17)
- MQ-8C Initial capability (4/18)

Program Essentials

Prime contractor: Northrop Grumman
Program office: Patuxent River, MD
Funding needed to complete:
R&D: $129.8 million
Procurement: $731.6 million
Total funding: $861.5 million
Procurement quantity: 16

Program Performance (fiscal year 2016 dollars in millions)

	As of 12/2006	Latest 12/2014	Percent change
Research and development cost	$641.6	$1,233.0	92.2%
Procurement cost	$1,805.3	$1,684.9	-6.7%
Total program cost	$2,806.1	$2,917.9	4.0%
Program unit cost	$15.854	$41.685	162.9%
Total quantities	177	70	-60.5%
Acquisition cycle time (months)	104	169	62.5%

Cost and quantity data are for development and procurement of both the MQ-8B and MQ-8C variants.

The MQ-8 program, which consists of a B and C variant, was restructured in 2015 as it reported a Nunn-McCurdy unit cost breach of the critical threshold. According to program officials, the requirement for the system to operate from the Littoral Combat Ship was updated to include the MQ-8C and the MQ-8B, resulting in a stoppage of MQ-8B production, decreased quantities, and increased unit cost. The MQ-8C is a larger airframe but shares previously developed technology from the MQ-8B. As a result of the Nunn-McCurdy breach, the program's schedule has been revised. According to program officials, the program's recertification of production is scheduled for May 2016, with the start of operational testing in September 2017 and initial operational capability for MQ-8C in April 2018.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in aan operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	▪▪▪▪
• Demonstrate critical processes on a pilot production line	●
• Test a production-representative prototype	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

Fire Scout Program

Technology and Design Maturity

According to the program office, MQ-8C has 90 percent commonality with the previously developed MQ-8B, the primary difference being structural modifications to accommodate the MQ-8C's larger airframe and fuel system. The MQ-8C relies on mature technologies common to the MQ-8B and has completed all of its planned engineering design drawings as of August 2014. The MQ-8C was initiated under the Navy's rapid deployment capability procurement process, which enabled the program to bypass many standard acquisition practices. According to program officials, this process traded concurrency risk for a speedier acquisition cycle time. First flight for the MQ-8C occurred in October 2013. The program will continue with developmental testing and transition to operational testing in the third quarter of fiscal year 2017. Despite the separate iteration of development, the MQ-8C did not have a separate system development start decision, which, according to program officials, was not required.

Production Maturity

The program awarded a contract for development and production of the MQ-8C in April 2012 after production of the MQ-8B variant stopped. The program has subsequently acquired 19 MQ-8C aircraft using the Navy's rapid deployment capability procurement process. According to program officials, these 19 units will be considered low-rate initial production units for the planned May 2016 production recertification decision. There will be additional low-rate initial production units procured after this May 2016 decision, but according to program officials this quantity has not been determined. We could not assess whether critical manufacturing processes were in control, as the program does not collect data on statistical process controls or assess process capabilities using manufacturing readiness levels. The program office collects metrics on the status of production from the prime contractor, such as discovery of manufacturing defects. Program officials noted that the MQ-8C air vehicle is a commercial airframe procured by the government and provided directly to the prime contractor as government furnished equipment for conversion to a MQ-8C. The prime contractor is responsible for integration of the avionics and working with the aircraft manufacturer to modify the commercial airframe with increased capacity fuel tanks, new electrical systems, and provisions for the unmanned avionics.

Other Program Issues

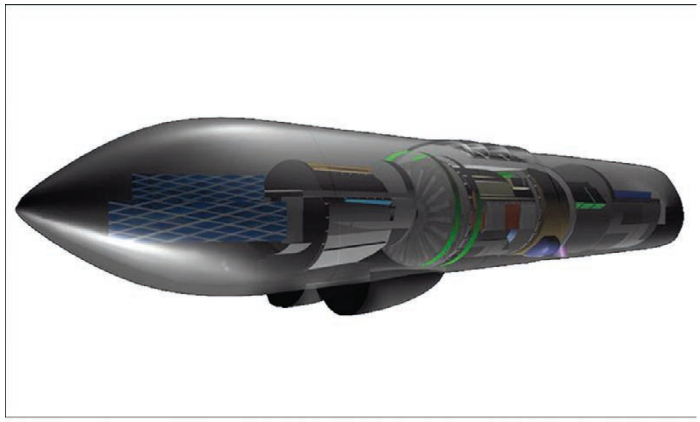
Current issues with the Littoral Combat Ship have made ship availability for testing with the MQ-8 difficult. According to program officials, continued difficulties with scheduling may affect planned initial operational test and evaluation dates. Further, continued software integration between the MQ-8C and the Littoral Combat Ship also depends on ship availability. After a Nunn-McCurdy unit cost breach of the critical threshold, in June 2014 the program was certified as essential to national security and allowed to proceed. The restructured program plans to seek approval of the new acquisition program baseline and recertification of the production decision in May 2016.

Program Office Comments

In commenting on a draft of this assessment, the program officials stated that the MQ-8 program is executing with no significant issues. A land-based operational assessment of the MQ-8C was completed by the Navy's Operational Test and Evaluation Force in November 2015. The event successfully completed all 72 test points and objectives, executing 82.4 flight hours in 17 days at the Point Mugu Test Range. The MQ-8B continues to support the Littoral Combat Ship with on-going deployments.

Next Generation Jammer Increment 1

The Navy's Next Generation Jammer (NGJ) is being developed as an external jamming pod system fitted on EA-18G Growler aircraft. It is expected to replace the ALQ-99 jamming pod system and provide enhanced airborne electronic attack capabilities to disrupt and degrade enemy air defense and ground communication systems. The Navy plans to field capabilities in three increments for different radio frequency ranges, beginning with Increment 1 (mid-band) in 2021, with Increments 2 and 3 (low- and high-band) to follow. We assessed Increment 1.



Source: U.S. Navy.

Concept | System development | Production

- Program start (7/13)
- GAO review (1/16)
- Deployment start (2/16)
- Design review (3/17)
- Low-rate decision (8/19)
- End operational test (4/21)
- Initial capability (6/21)
- Full-rate decision (3/22)

Program Essentials

Prime contractor: Raytheon
Program office: Patuxent River, MD
Funding needed to complete:
R&D: $2,409.6 million
Procurement: $4,069.6 million
Total funding: $6,483.3 million
Procurement quantity: 124

Program Performance (fiscal year 2016 dollars in millions)

	As of	Latest 02/2015	Percent change
Research and development cost	N/A	$3,325.9	N/A
Procurement cost	N/A	$4,069.6	N/A
Total program cost	N/A	$7,399.7	N/A
Program unit cost	N/A	$57.810	N/A
Total quantities	N/A	128	N/A
Acquisition cycle time (months)	N/A	95	N/A

NGJ plans to enter system development in February 2016, with its seven critical technologies all nearing full maturity. Consistent with best practices and statutory requirements, the program completed a preliminary design review in October 2015 prior to its planned development start. However, risks remain in several areas, in particular meeting weight and power requirements and integrating the jamming pods with the aircraft. The NGJ program has taken multiple steps to reduce design and integration risks prior to development start, but it does not plan to implement one key best practice–demonstrating a system-level prototype prior to its critical design review. In September 2015, the Under Secretary of Defense for Acquisition, Technology, and Logistics approved the NGJ Increment 1 to participate in a pilot program that allows it to streamline and tailor some acquisition processes.

Attainment of Product Knowledge

Projected as of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• *Release at least 90 percent of design drawings*	
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
.... Information not available
Not applicable

NGJ Increment 1 Program

Technology Maturity

The NGJ program plans to enter system development in February 2016, with its critical technologies approaching full maturity. In November 2015, the program conducted an assessment of its seven critical technologies, which include two separate arrays–each with different transmit/receive modules, circulators, and apertures–as well as a power generation system. All technologies were assessed as nearing maturity based on subsystem prototyping testing conducted prior to system development start.

Design Maturity

According to program officials, the Navy has identified and taken steps to mitigate several key design and integration risks. The program considers achieving the necessary power within weight constraints to be the greatest risk. Additional risks include integration of the NGJ with the EA-18G and the potential for electromagnetic radiation to affect the reliability of missiles employed on the EA-18G. The program has taken several steps to mitigate these risks. According to officials, the program instituted efforts to reduce the weight of multiple subsystems, included incentive fees related to weight and power in the development contract, and received approval for a higher pod weight by making trades with the EA-18G. In addition, the program has established working groups to address NGJ and EA-18G software and hardware interoperability.

The NGJ program has taken multiple steps to reduce design risk prior to development start, but it does not plan to implement one key best practice intended to demonstrate the maturity of the system's design at its critical design review. Consistent with best practices and statutory requirements, the program completed a preliminary design review in October 2015 prior to its planned development start. Holding preliminary design review before the start of system development helps ensure that requirements are defined and feasible and the proposed design can meet those requirements within cost, schedule, and other system constraints. The program does not plan to test an early system prototype of the jamming pod before its March 2017 critical design review. Best practices call for such testing to take place before the critical design review to help determine whether the design is stable and will work as intended. The first test of a fully functional jamming pod is planned for March 2019. Program officials believe that the significant prototyping and associated testing conducted to date addresses the principal program risks, including how to meet key performance requirements within design constraints, such as the size and weight of the pod.

Other Program Issues

In September 2015, the Under Secretary of Defense for Acquisition, Technology, and Logistics approved NGJ as the first program in the Skunk Works pilot, which aims to eliminate non-value added processes in order to deliver capabilities on time and within budget. The Navy and DOD are streamlining documentation and review processes and have delegated documentation approval authority to lower levels where appropriate. For example, the program streamlined the process for conducting its technology readiness assessment by reviewing key test results with DOD and Navy representatives and documenting those results in a memo instead of a formal Technology Readiness Assessment report.

Program Office Comments

In commenting on a draft of this assessment, the NGJ program said it has designed and resourced extensive prototype testing, focused on technical risks, which has led to early discovery of issues, minimized risks for the development phase, and put the program on solid footing for production and deployment. Prototype testing was conducted at the component-level and subsystem-level. This testing informed the preliminary design. The program stated that it also leveraged model performance predictions, which were informed by and updated as the system progressed through testing. According to the program, primary prototype testing is complete and test results indicated effective isotropic radiated power and prime power requirements were met. The program noted changes from prototype designs to preliminary design are being minimized to further reduce system development risk. Technical comments were provided by the program office, which were incorporated where deemed appropriate.

Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1)

The Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1) is a Navy-led program to develop an air-launched, long-range, anti-surface warfare missile to address an urgent operational need. The program is using an accelerated acquisition approach and is leveraging previous technology demonstration efforts. It plans to field an early operational capability on Air Force B-1 bombers in 2018 and Navy F/A-18 aircraft in 2019. DOD is developing requirements for Increment 2 to address the threat in 2024 and beyond.

Source: U.S. Navy.

Concept | **System development** | **Production**

- GAO review (1/16)
- Deployment start (2/16)
- Design review (6/16)
- Start operational test (10/17)
- Low-rate decision (11/17)
- Early operational capability B-1 (9/18)
- Early operational capability F/A-18 (8/19)

Program Essentials

Prime contractor: Lockheed Martin
Program office: Patuxent River NAS, MD
Funding needed to complete:
R&D: $761.9 million
Procurement: $311.9 million
Total funding: $1,073.8 million
Procurement quantity: 110

Program Performance (fiscal year 2016 dollars in millions)

	As of	Latest 06/2015	Percent change
Research and development cost	N/A	$1,111.7	N/A
Procurement cost	N/A	$311.9	N/A
Total program cost	N/A	$1,423.6	N/A
Program unit cost	N/A	$11.481	N/A
Total quantities	N/A	124	N/A
Acquisition cycle time (months)	N/A	31	N/A

The latest cost and quantity data are for fiscal years 2013 through 2019 for the acquisition of Increment 1 capability. The timeline dates depict when equivalent decision reviews will occur.

In order to meet urgent operational needs, the OASuW Inc 1 program plans to enter system development in February 2016 with less knowledge than recommended by best practices. Only one of its six critical technologies is nearing full maturity the other technologies are expected to be near maturity by the planned June 2016 critical design review. The program plans to release more than 90 percent of the drawings by critical design review but this estimate may not include all the subsystems being developed. The accelerated acquisition approach includes concurrency between developmental testing and production which increases the risk of late design changes and costly retrofits after production has started. The program is attempting to mitigate this concurrency risk by leveraging airframe commonality with the JASSM-ER missile and through early, targeted sub-system testing.

Attainment of Product Knowledge

Projected as of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	○
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• *Release at least 90 percent of design drawings*	
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained ▪▪▪▪ Information not available
○ Knowledge not attained *Not applicable*

OASuW Inc 1 Program

Technology Maturity

OASuW Inc 1 is scheduled to enter system development in February 2016 with none of its six critical technologies mature and one approaching full maturity which is not consistent with best practices. Only algorithms for electro-optical sensing have been demonstrated in a relevant environment. The program's single hardware-based critical technology–a radio frequency sensor–and four other software-based ones–autorouter, low altitude control/sea state estimator, multi-target tracker, and simultaneous time of arrival algorithms–are immature. Program officials estimate that all critical technologies will be approaching maturity prior to critical design review in June 2016, but delays may occur if the low altitude control algorithm requires further development.

Design and Production Maturity

Although it is proceeding with immature technologies, the program completed a preliminary design review in October 2014 prior to entering system development. The program estimates that 97 percent of design drawings will be releasable by critical design review. Although a recent independent systems engineering review found that the program's design appears to be progressing with a well understood critical path and actively mitigated risks, it called for better linkage between requirements and design and noted that design drawing estimates may not include all mission systems under development.

OASuW Inc 1 builds upon the knowledge gained by the Defense Advanced Research Projects Agency's (DARPA) Long Range Anti-Ship Missile (LRASM) program–which included three test flights–and leverages the airframe and production facilities of the Joint Air-to-Surface Standoff Missile-Extended Range (JASSM-ER) program. However, the JASSM-ER fuze–a planned component of the OASuW missile design–is not qualified for use on Navy weapons. The program is seeking approval to accept the associated risk. If not granted, development of an alternate fuze may cause delays. An OASuW-specific production maturity assessment will be conducted in support of a production readiness review scheduled for November 2016.

Other Program Issues

Maintaining the program's schedule is the primary concern for OASuW Inc 1 as it intends to address an urgent operational need. The program's current accelerated acquisition approach consists of decision points that align with key systems engineering reviews, test events, contract actions, and fielding decisions. The approach requires concurrency between initial production and developmental testing, which entails certain risks. Our past work has shown that beginning production before demonstrating that a design is mature and will work as intended increases the risk of discovering deficiencies during production that could require design changes, costly modifications, and retrofits. The program has accepted this risk and mitigated it, in part, by limiting the program to the 110 missiles needed to provide a capability until the second increment is fielded. According to program officials, requirements stability for Increment 1 must be maintained to keep capabilities at a level that satisfies warfighter needs and mitigates potential schedule risks from additional development and design activities. Program officials state that they have been successful in removing capabilities found to be extraneous to meeting operational requirements.

Program Office Comments

In commenting on a draft of this assessment, Navy officials noted that OASuW Inc 1 exists to fill an urgent need and emerging capability gap and to pace the growing maritime threat. They added that timing to field OASuW capability is paramount. As a result, the acquisition strategy was planned with concurrent system qualification and test, which does introduce risk. To reduce risk the program leveraged the mature JASSM-ER platform, with which 88 percent is common, and demonstrated technology maturity during three successful DARPA flight tests. According to the program, LRASM's hardware design is also mature with technical margins that minimize the risk of later hardware changes. LRASM-unique components also leverage legacy systems to reduce technical and schedule risk. Finally, OASuW Inc 1 has progressed from program initiation through critical design review in 18 months and is on track to field on schedule. The Navy also provided technical comments, which were incorporated as appropriate.

Ship to Shore Connector Amphibious Craft (SSC)

The Navy's SSC is an air-cushioned landing craft intended to transport personnel, weapon systems, equipment, and cargo from amphibious vessels to shore. SSC is the replacement for the Landing Craft, Air Cushion, which is approaching the end of its service life. The SSC is designed to deploy in Navy well deck amphibious ships, such as the LPD 17 class, and for use in assault and nonassault operations. The program entered system development in July 2012 and held its low-rate production decision in May 2015.

Source: U.S. Navy.

Concept | **System development** | **Production**

- Program start (5/09)
- Development start (7/12)
- Design review (9/14)
- Low-rate decision (5/15)
- GAO review (1/16)
- Complete operational test (3/18)
- Full-rate decision (9/18)
- Initial capability (8/20)

Program Essentials

Prime contractor: Textron Inc.
Program office: Washington, DC
Funding needed to complete:
R&D: $17.9 million
Procurement: $3,391.7 million
Total funding: $3,429.5 million
Procurement quantity: 69

Program Performance (fiscal year 2016 dollars in millions)

	As of 07/2012	Latest 08/2015	Percent change
Research and development cost	$597.2	$525.6	-12.0%
Procurement cost	$3,624.4	$3,541.1	-2.3%
Total program cost	$4,241.6	$4,086.5	-3.7%
Program unit cost	$58.104	$55.980	-3.7%
Total quantities	73	73	0.0%
Acquisition cycle time (months)	135	135	0.0%

The SSC program entered production in May 2015, with its critical technology mature and design stable, but before demonstrating that critical processes were in control. The program recently completed design changes to the drive train gearbox, which is among the items the program has identified as potential risk areas. Other risks remain, including operational challenges posed by the steep angle of the craft's loading ramp and low productivity in software development. According to program officials, SSC did not meet two required production exit criteria and plans to have eight craft under contract–with four starting fabrication–prior to delivery of the test craft, posing risks if issues are identified during testing. A planned 4 year block buy contract starting in fiscal year 2017 will result, if approved, in authorizing 33 craft before the test craft is delivered.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
Demonstrate all critical technologies in a relevant environment	●
Demonstrate all critical technologies in an operational environment	●
Complete preliminary design review	●
Product design is stable	
Release at 90 percent of design drawings	●
Test a system-level integrated prototype	○
Manufacturing processes are mature	
Demonstrate critical processes are in control	○
Demonstrate critical processes on a pilot production line	●
Test a production-representative prototype	○

● Knowledge attained
○ Knowledge not attained
.... Information not available
Not applicable

SSC Program

Technology and Design Maturity

The program's single critical technology, the fire suppression system, is mature and the design stable. The program recently completed design changes due to concerns with accelerated wear of the drive train gearbox. The gearbox was not ready for factory acceptance testing prior to production, but the program believes that recent design changes will address the wear issues.

In May 2015, the Navy's commander of operational test and evaluation reported that the steep angle of SSC's loading ramp may create operational hazards for certain vehicle types. The program will not have an opportunity to fully assess this and other issues until the completion of developmental testing in December 2017, 6 months earlier than previously planned due to a recent decision to use two craft for testing–100 and 101–instead of one.

Development of command, control, communication, computer and navigation system software has been less productive than planned, leading Navy cost estimators to find that software development costs would likely significantly exceed current estimates, and that the fixed-price software development contract will only partially mitigate the budgetary impact of this cost growth.

Production Maturity

The program was approved for low-rate production in May 2015, 3 months later than planned. According to program officials, at the time of the decision the SSC had not met two of the 13 exit criteria required to enter low-rate production–both related to the gearbox–but was planning to meet those remaining criteria by January 2016. Program officials stated that the program has experienced some production delays, but that it is still within 2 to 3 months of its schedule. Fabrication of the test and training craft began in November 2014 and was 16 percent complete as of July 2015. Delivery is projected for May 2017 with delivery of the second craft in August 2017. The delivery of the test craft is critical because it is the first opportunity to demonstrate whether capabilities meet requirements and that no redesign work is needed before committing to production of additional craft.

The program currently plans to have eight craft under contract–with four starting fabrication–prior to delivery of the test craft. Our previous work has shown that such concurrency can increase the risk of discovering deficiencies in testing that could require costly design changes and modifications to systems already produced. As a result of the program's concurrent testing and production schedule, it will not demonstrate that the craft function reliably in an operational environment until fiscal year 2018. Any deficiencies that are discovered would require correction on the eight craft already in production.

Other Program Issues

The SSC program office is considering a single block buy contract– which is typically similar to a multiyear contract, but without the same statutory limitations–for fiscal years 2017 through 2020, for a total of 33 craft. Program officials believe this approach, which, if this authority is enacted by Congress, would provide more stability for the vendors and reduce costs compared to an annual procurement. However, committing to a contract for several years of production before delivering the test craft introduces additional risk. If issues requiring design changes are identified during developmental testing–not scheduled for completion until the end of 2017–the program could face costly rework of craft already in production.

Program Office Comments

In commenting on a draft of this assessment, program officials stated that the SSC schedule, while containing some concurrency, is the most affordable approach, leveraging production efficiencies while addressing rising sustainment costs for the current fleet. The program is mitigating concurrency by use of incremental decision points before craft awards, design maturity, and rigorous testing. Eliminating concurrency would drive increased sustainment funding and create a production break, risking loss of workforce expertise, increasing manufacturing overhead costs and reducing opportunities for economic quantity buys. Regarding the gearbox, this last production exit criterion will be complete with the first article test that starts in January 2016. Regarding software cost, revised projections suggest lower costs. Forecasts in 2014 presumed coding inefficiencies that have not materialized to date. Regarding the ramp, the SSC geometry is similar to existing craft. An initial assessment was completed in August 2015. A final technical solution is under development.

VH-92A Presidential Helicopter Replacement Program

The Navy's VH-92A program provides new helicopters for executive transport of the President, Vice President, heads of state, and others. A successor to the VH-71 program–canceled due to cost growth, schedule delays, and performance shortfalls–the planned fleet of 23 VH-92A aircraft will replace 23 legacy helicopters. The VH-92A is expected to provide improved operational performance and communications capabilities, while offering increased passenger payload. Until VH-92As are available, the Navy is ensuring legacy fleet availability.

Source: Sikorsky Aircraft Corporation.

Concept | **System development** | **Production**

- Material development decision (3/10)
- Development start (4/14)
- GAO review (1/16)
- Design review (7/16)
- Low-rate decision (1/19)
- Operational test complete (3/20)
- Initial capability (7/20)
- Full-rate decision (5/21)

Program Essentials

Prime contractor: Sikorsky Aircraft Corporation
Program office: Patuxent River, MD
Funding needed to complete:
R&D: $2,014.7 million
Procurement: $2,127.5 million
Total funding: $4,142.3 million
Procurement quantity: 17

Program Performance (fiscal year 2016 dollars in millions)

	As of 04/2014	Latest 07/2015	Percent change
Research and development cost	$2,684.8	$2,689.3	0.2%
Procurement cost	$2,104.8	$2,127.5	1.1%
Total program cost	$4,789.5	$4,816.8	0.6%
Program unit cost	$208.241	$209.428	0.6%
Total quantities	23	23	0.0%
Acquisition cycle time (months)	76	75	-1.3%

The VH-92A is using an existing platform and incorporating mature technologies. While no new technologies are involved, the fully configured mission communications system has yet to be tested in an aircraft. Initial ground and flight testing consisting of antenna co-site interference and system performance has been conducted. The preliminary design review was completed in August 2015, 15 months after the start of system development. Prior to this, the Navy, along with the users, reduced risk through the requirements management process. The contractor also recommended alternative icing test methods. As of December 2015, the contractor completed 60 percent of its design drawings and plans to release over 90 percent by critical design review scheduled for July 2016. The contractor is producing two engineering development models to perform contractor testing in 2017 and Navy testing in 2018.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• *Release at least 90 percent of design drawings*	
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

VH-92A Program

Technology and Design Maturity

The VH-92A program began system development in April 2014 with its mission communications system (MCS), a new system with technology critical to the mission, approaching full maturity. The program is modifying a commercially available aircraft for the VH-92A, using upgraded technologies that are already on the legacy fleet. The sole exception is the government designed MCS. According to officials, on-site government program monitors identified a potential information assurance risk that could delay the delivery of MCS–a subcomponent lacks the certification documents needed to ensure information is safeguarded to standards. Another potential risk for the program is aircraft weight growth. For example, the MCS and a companion system exceeded their allowed weight limit. The contractor implemented a weight improvement program and reduced the weight to address this problem. The system-level preliminary design review was held in August 2015, 15 months after system development start, as the program received a waiver to the statutory requirement for holding it before this milestone. The preliminary design review resulted in 12 actions that require an approved response. Eleven of the 12 have been closed and the last one–stabilization of a communication system component to prevent vibrations is planned for closure in early 2016–has yet to be approved. In September 2015, two baseline S-92A aircraft were inducted into the contractor's facility to commence modifications and become the two engineering development aircraft, 4 months earlier than planned. One had previously been used to test antenna placement and to conduct MCS test activities.

As of December 2015, the contractor released 60 percent of the engineering design drawings. The contractor plans to release 90 percent by the critical design review, scheduled for July 2016. These drawings represent the new or modified equipment on the aircraft.

Production Maturity

The program does not plan to collect statistical process control data for critical manufacturing processes, but will instead use manufacturing readiness levels. The program plans to reach DOD’s recommended level of manufacturing process maturity for the start of production, but not a level that indicates processes are in control as recommended by best practices.

Other Program Issues

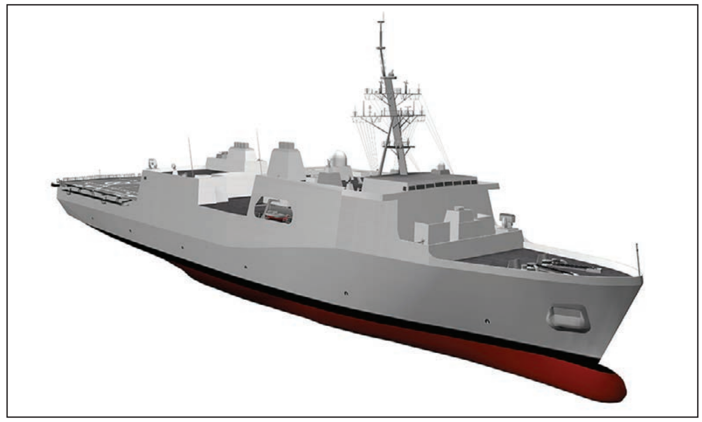
The Navy determined through its requirements management process that it no longer needed the contractor to meet a certain requirement. Costs to design and implement a capability for that requirement were included in the negotiated target contract price, as this capability is not included in the baseline S-92A aircraft. According to program officials, the capability is unnecessary due to the helicopter's operating conditions. The Navy requested Sikorsky to develop and submit a credit proposal for a contract price adjustment to account for the change. The contractor's original plan to conduct flight testing to meet the requirement for flight operations in icing conditions has been revised to eliminate the flight tests. The baseline S-92A is currently certified for flight operations in icing conditions, and the contractor has determined that the VH-92A configuration can be certified through modeling and analysis. The schedule savings resulting from the elimination of the icing tests is being applied to other program activities.

Program Office Comments

In commenting on a draft of this report, the program office noted that the planned VH-92A fleet of 23 aircraft includes 21 operational aircraft and 2 test aircraft, the engineering development model aircraft being produced in the engineering and manufacturing development phase of the program. The legacy fleet includes two test aircraft and recently received two dedicated training aircraft, bringing their total to 23 aircraft. During calendar year 2015, the program completed its development milestones as planned and cost estimates are within the baseline approved at the system development start review. According to program officials, the program is on track to complete its critical design review later this year as planned. The program office also provided technical comments, which were incorporated where deemed appropriate.

Amphibious Ship Replacement (LX(R))

The Navy's LX(R) program plans to build a new class of ships to replace existing amphibious ships. The primary function of these ships is to transport U.S. Marines and their equipment to distant operating areas and enable expeditionary operations ashore. The LX(R) will include a larger hull than the retiring ships and can also be used for non-combat operations due to its storage space and ability to transfer people and supplies. Starting in fiscal year 2020, the Navy plans to procure 11 ships with delivery of the first LX(R) in 2026.



Source: Computer Science Corp (CSC) pursuant to LX(R) Design Support Contract.

Current Status

Based on an analysis of alternatives, the Navy decided in October 2014 to base the LX(R) design on the San Antonio (LPD 17) class amphibious ships. The Navy stated that by modeling the LX(R) on an existing ship it would leverage existing design maturity and reduce the cost risks associated with a new design. Navy officials stated that there are no new critical technologies planned. Since the existing LPD 17 design is considered unaffordable for the LX(R) program, the Navy plans to remove some features to significantly reduce LPD 17 ship costs while still ensuring that the new design satisfies all LX(R) requirements.

The Navy is using a limited competition approach that combines LX(R) design efforts with acquisition activities for the next America Class Amphibious Assault Ship (LHA 8) and Fleet Replenishment Oiler (T-AO(X)), to maintain stability within the shipbuilding industrial base. The Navy issued a combined solicitation in June 2015 that was limited to two contractors–Huntington Ingalls Industries and General Dynamics NASSCO–for detail design and construction of T-AO(X) and LHA 8 ships, as well as early stage design work for LX(R). The Navy was appropriated $250 million in fiscal year 2016 for advanced procurement, funds that will be used for engineering, and planning for the lead LX(R) ship, and plans to award a contract for construction in 2020. The acquisition strategy for this phase of the program is not finalized and the shipbuilders who will compete to build LX(R) have not yet been determined. The program's entrance into system development, as well as the designation of the milestone decision authority, will be made following the approval of the program's requirements.

Estimated Program Cost and Quantity (fiscal year 2016 dollars):
Total program: $17,130 million
Research and development: $168 million
Procurement: $16,962 million
Quantity: 11

Next Major Program Event: Requirements validation, fiscal 2016

Program Office Comments: In commenting on a draft of this assessment, the Navy provided technical comments which, were incorporated as appropriate.

DDG 51 Flight III Destroyer (DDG 51 Flight III)

The DDG 51 Flight III destroyer will be a multimission ship designed to operate against air, surface, and subsurface threats. Compared to existing Flight IIA ships, Flight III will provide increased ballistic missile and area air defense capabilities. Planned configuration changes for Flight III include replacing the current SPY-1D(V) radar with the new Air and Missile Defense Radar (AMDR). The Navy plans to acquire a total of 22 Flight III ships beginning in fiscal year 2016.

Source: Bath Iron Works.

Current Status

The Navy continues Flight III design activities, including the award of the detail design contracts in February 2015 and completion of a preliminary design review in September 2015. Flight III and AMDR development is concurrent, which could affect ship construction if delays occur in AMDR development or production. In addition to AMDR, Flight III changes include, among other things, upgrades to the ship's electrical plant. Power conversion modules and new generators similar to those developed for the DDG 1000 class are to supply the increased power needed for AMDR. The DDG 1000 program had issues in developmental testing of its electrical system, and additional modifications are required for Flight III. The Flight III design also includes configuration changes to increase weight and stability margins, which determine how much new equipment can be incorporated into the ship. The Navy stated that it believes that the new equipment's additional weight will not adversely affect Flight III performance, but the ship's internal space is a risk that it is monitoring. The addition of AMDR and system upgrades will account for the majority of the increased margins and may limit the ability to introduce future upgrades.

The Navy plans to modify, using an engineering change proposal, the existing Flight IIA multiyear procurement contracts in order to construct the first three Flight III ships rather than awarding new contracts. In February 2015, the Navy submitted a report to Congress on the engineering change proposal, reiterating that the low to moderate risks associated with AMDR and the proposed system upgrades justifies its execution within the next year. The Navy plans to award construction of the first Flight III ship in the third quarter of fiscal year 2016 and two follow-on ships in fiscal year 2017.

Estimated Program Cost and Quantity (fiscal year 2016 dollars):
Total program: $43,381.5 million
Research and development: $4,038.3 million
Procurement: $39,343.2 million
Quantity: 22 (procurement)

Next Major Program Event: Award of first Flight III engineering change proposal, fiscal year 2016.

Program Office Comments: In commenting on a draft of this assessment, the Navy noted that ship design and AMDR engineering and manufacturing development remain on track.

Fleet Replenishment Oiler (T-AO(X))

The T-AO(X) program is intended to replace the Navy's 15 existing T-AO 187 Class Fleet Oilers, which are nearing the end of their service lives. Its primary mission is to provide replenishment of bulk petroleum products, dry stores/packaged cargo, fleet freight, mail, and personnel to other vessels while underway. The Navy plans to procure a total of 17 ships, starting with the first T-AO(X) in fiscal year 2016 and the remaining ships at a rate of one per year beginning in fiscal year 2018.

Source: U.S. Navy. Notional Concept T-AO(X)

Current Status

The Navy has completed cost and capabilities trade studies, which suggest that T-AO(X) will be able to meet minimum capability requirements within projected costs utilizing commercial ship designs and technologies. The Navy plans to employ military unique systems for specific functions, such as underway replenishment. According to an October 2014 technology readiness assessment, the program's three critical technologies are fully mature based on the results of land-based and at-sea prototype testing. The most notable of these technologies, Heavy-Electric Standard Tension Replenishment Alongside Method, allows the transfer of cargo at double the standard speed or, alternatively, double the standard load weight. These technologies are required to meet the more robust requirements for underway replenishment associated with the new Ford-class aircraft carriers. Due to its plans to use a commercial design, the program was granted a waiver for the requirement to conduct competitive prototyping and plans to request a waiver for preliminary design review prior to the start of system development.

After approval in June 2015, the Navy released its request for proposals to two companies under a tailored T-AO(X) acquisition strategy. The Navy is using a limited competition acquisition strategy that combines T-AO(X) with acquisition activities for its amphibious ships LHA and LX(R), which it believes will maintain stability within the shipbuilding industrial base. The Navy anticipates awarding a fixed-price incentive contract in May 2016 for lead ship detail design and construction. Navy officials indicated that the remaining ships will be acquired at a rate of one ship per year under two additional contracts, possibly using firm fixed-price contracts. The program's estimated costs and buy profile beyond fiscal year 2020 are under development.

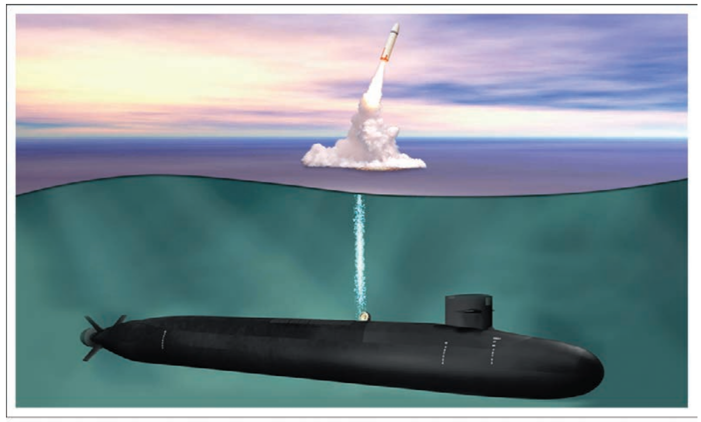
Estimated Program Cost and Quantity (fiscal year 2016 dollars):
Total program (fiscal years 2011-2020): $2,381 million
Research and development (fiscal years 2011-2014): $56.1 million
Procurement (fiscal years 2016-2020): $2,324.9 million
Quantity: 4

Next Major Program Event: System development start, May 2016

Program Office Comments: In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

OHIO-CLASS REPLACEMENT (OR)

The Navy's Ohio-class Replacement (OR) will replace the current fleet of Ohio-class ballistic missile submarines (SSBNs) as they begin to retire in 2027. The Navy began technology development in January 2011 in order to avoid a gap in sea based strategic deterrence between the Ohio-class's retirement and the production of a replacement. Costs for the OR program are expected to account for approximately one-sixth of the Navy's shipbuilding budget for the next 30 years, even as annual shipbuilding budgets rise above the historical average.



Source: © 2012 General Dynamics Electric Boat.

Current Status

The program is developing and conducting tests of a prototype interface for the OR's ship control system and other new technologies while focusing on production readiness. The Navy released the Integrated Process and Product Development request for proposals (RFP) in January 2016, and anticipates awarding the contract by October 2016. Prior to the start of system development in August 2016, the program plans to hold a preliminary design review to validate the design is stable. Development start will be followed by the release of the RFP for long lead time materials planned for September 2018. According to program officials, construction has begun on two testing facilities: one to test the missile fire control systems using production representative systems and one to test the systems that eject the missile from the launch tube. Both shipyards are using an improved computer-based design tool which speeds the transition from design to construction and helps develop an efficient build strategy. The lead shipyard is finishing construction of a representative hull section to validate the fidelity of the new design tool. The program plans to complete the three-dimensional model prior to starting ship construction, an important step in reducing the risk of cost growth as identified by GAO's best practices for shipbuilding. The lead shipyard has also constructed a new manufacturing building and is installing new manufacturing fixtures.

According to program officials, the Joint Requirements Oversight Council validated the OR's requirements in August 2015. The program office continues to investigate cost saving options. One option, which would require additional congressional approval, includes leveraging Virginia class and OR acquisitions using a multiyear procurement to facilitate economic order quantity purchases across both submarine programs.

Estimated Program Cost and Quantity (fiscal year 2016 dollars):
Total program: $97,021.2 million
Research and development: $11,954.5 million
Procurement: $85,066.7 million
Quantity: 12

Next Major Program Event: System development start, August 2016

Program Office Comments: In commenting on a draft of this assessment, the Navy provided technical comments, which were incorporated where appropriate.

P-8A Increment 3

The Navy's P-8A Increment 3 program is intended to provide enhanced capabilities to the P-8A aircraft in two blocks. The first block is to include communications, radar, and weapons upgrades, which will be incorporated into the existing P-8A architecture as a series of discrete engineering change proposals. The second block will establish new open systems architecture and integrate improvements to the combat system's ability to process and display classified information and its search, detection, and targeting capabilities.

Source: U.S. Navy.

Current Status

In October 2013, the Under Secretary of Defense for Acquisition, Technology, and Logistics approved the P-8A Increment 3 program to bypass technology development and begin the acquisition process in system development, which is planned to begin in the third quarter of fiscal year 2017. The program plans to continue development of the P-8A Increment 3 capabilities as engineering change proposals, but it will conduct an overall preliminary design review in 2017. As the program bypassed technology development, it has not yet developed an independent cost estimate.

The P-8A Increment 3 program expects to deliver improved capabilities to the P-8A aircraft, while introducing competition and increasing government responsibilities as a part of future upgrades. Program officials stated that Increment 3 will require the integration of new hardware and software, but these capabilities will be based on mature technologies and no critical technologies have been identified. The Navy awarded sole-source contracts to Boeing–the P-8A prime contractor–to integrate Block 1 capabilities into the existing aircraft. For Block 2, the Navy is developing applications based on open systems architecture as an extension of the existing mission systems architecture, which will allow it to openly compete the development and integration of future combat system capabilities. This architecture upgrade is being competitively prototyped and executed as an open source, collaborative development. The Navy, which plans to act as systems integrator, awarded two software development contracts in 2014 to Lockheed Martin and Raytheon. Program officials said they will choose the best parts of each design during system development and integrate them into a single architecture. The hardware will be funded as a part of the operating and support costs of the P-8A.

Estimated Program Cost and Quantity (fiscal year 2016 dollars):
Total program: $1,003.6 million
Research and development: $1,003.6 million
Procurement: N/A
Quantity: 109

Next Major Program Event: Development request for proposal release decision, third quarter fiscal year 2016

Program Office Comments: In commenting on a draft of this assessment, program officials stated that the P-8A Increment 3 program continues to prepare acquisition documentation and the requests for proposals for future contracts that will support the integration of these future capabilities into the P-8A aircraft in a timely and cost effective manner.

Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) System

The Navy's UCLASS system is expected to address a gap in persistent sea-based intelligence, surveillance, reconnaissance, and targeting (ISR&T) and provide precision strike capabilities. The system is made up of three key segments: an air segment, a carrier segment, and a control system and connectivity segment.

Source: Jeff Hobrath, Chief, USN (Ret) President, Naval Tees, LLC.

Current Status

Release of the request for proposals for the design, fabrication, test, and delivery of the air system continues to be delayed pending the outcome of a review of all of DOD's ISR&T programs. According to program officials, while this review was completed in July 2015, no decision about UCLASS was made at that time, and discussions are expected to continue until the Office of the Secretary of Defense's (OSD) fiscal year 2017 budget submission.

GAO reported in May 2015 that the intended mission and required capabilities of UCLASS were under review, as there is ongoing debate within OSD about whether the primary role of the UCLASS system should be surveillance with limited strike capability or strike with limited surveillance capability. This debate has delayed the program. Award of the air system development contract is now expected in fiscal year 2017, a delay of about 3 years. The Navy now expects to achieve early operational capability–defined as a UCLASS system on at least one aircraft carrier–in fiscal year 2022, a delay of about 2 years.

GAO also reported that knowledge the Navy has obtained in developing UCLASS, including from reviewing the preliminary designs of four contractors, may no longer be completely applicable depending on what requirements are finally chosen. If the final UCLASS requirements emphasize a strike role with limited surveillance, the Navy will likely need to revisit the areas of technology, design, and funding which could further delay the award of an air system development contract. GAO therefore recommended that before committing significant resources, the Navy should ensure that it has an executable business case for UCLASS development that matches available resources to the required capabilities. The Navy generally agreed with the recommendation.

Estimated Program Cost and Quantity (fiscal year 2016 dollars):
Total program: TBD
Research and development (fiscal years 2012-2020): $3,043 million
Procurement: TBD
Quantity: TBD

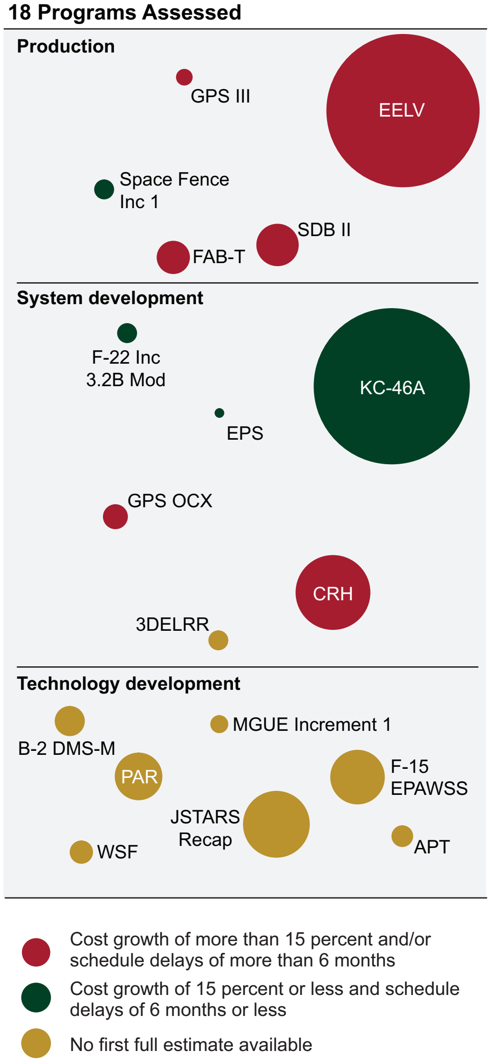
Next Major Program Event: Release request for proposals for design, fabrication, test, and delivery of air system.

Program Office Comments: In commenting on a draft of this assessment, the Navy provided technical comments, which were incorporated as appropriate.

Air Force Service Summary

We performed in-depth assessments on 11 of the 26 Air Force major defense acquisition programs in the current portfolio that for the most part are in system development or the early stages of production. We also assessed seven programs identified as future major defense acquisition programs that are expected to enter system development in the next few years. The Air Force currently estimates a need of more than $103 billion in funding to complete the acquisition of these programs. The programs in system development or production, where we determined cost and schedule change from first full estimates, have experienced more than $39 billion in cost growth and average schedule delays of approximately 18 months. More of the cost growth for Air Force programs occurred in the past 5 years than prior to that time, primarily due to cost changes on the Evolved Expendable Launch Vehicle program. Of these same programs, four have completed all the activities associated with the applicable knowledge-based best practices we assess.

Acquisition Phase and Size of the 18 Programs Assessed

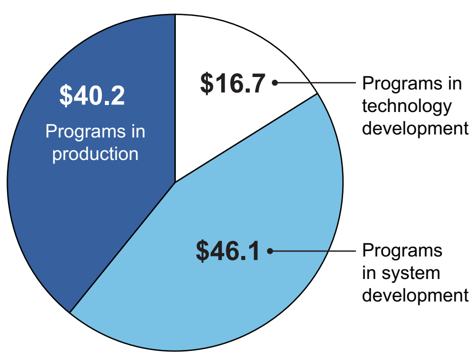


Note: Bubble size is based on each program's currently estimated future funding needed.

Source: GAO analysis of DOD data. | GAO-16-329SP

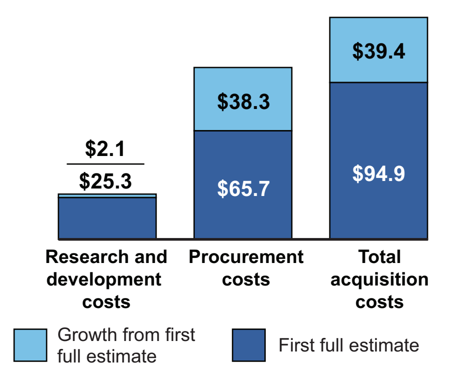
Currently Estimated Acquisition Cost for the 18 Programs Assessed

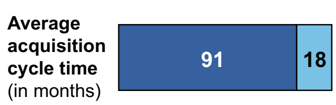
Fiscal year 2016 dollars in billions



Cost and Schedule Growth on 10 Programs in the Current Portfolio

Fiscal year 2016 dollars in billions





Note: In addition to research and development and procurement costs, total acquisition cost includes acquisition related operations and maintenance and system-specific military construction costs.

Summary of Knowledge Attained to Date for Programs Beyond System Development Start

Program common name	Knowledge Point (KP) 1 Resources and requirements match	Knowledge Point 2 Product design is stable	Knowledge Point 3 Manufacturing processes are mature
CRH	○	KP 2 in future	KP 3 in future
EPS	●	●	KP 3 in future
EELV	●	■	■
F-22 Inc 3.2B Mod	●	●	KP 3 in future
FAB-T	○	●	○
GPS III	●	●	○
GPS OCX	○	KP 2 in future	KP 3 in future
KC-46A	○	●	KP 3 in future
SDB II	●	●	●
Space Fence Inc 1	●	○	■
3DELRR	○	KP 2 in future	KP 3 in future

● All applicable knowledge practices were completed

○ One or more applicable knowledge practices were not completed

■ All knowledge practices were not applicable

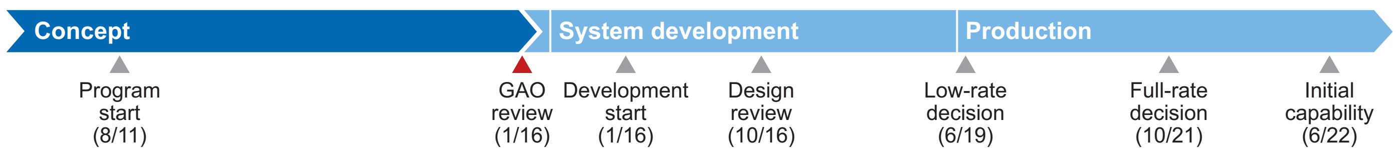
- - - Information not available for one or more knowledge practice

Air Force Program Assessments

B-2 Defensive Management System Modernization (B-2 DMS-M)

The Air Force's B-2 DMS-M program is expected to upgrade the aircraft's 1980s-era analog defensive management system to a digital capability. The program intends to improve the frequency coverage and sensitivity of the system, update pilot displays, and enhance in-flight replanning capabilities to avoid unanticipated air defense threats. It also expects to improve the reliability and maintainability of the DMS system and the B-2's readiness rate.

Source: U.S. Air Force.



Program Essentials

Prime contractor: Northrop Grumman Corp
Program office: Wright-Patterson AFB, OH
Funding needed FY 2016 to FY 2020
R&D: $941.2 million
Procurement: $292.4 million
Total funding: $1,233.6 million
Procurement quantity: 20

Program Performance (fiscal year 2016 dollars in millions)

	As of	Latest 10/2015	Percent change
Research and development cost	N/A	$1,671.9	N/A
Procurement cost	N/A	$272.4	N/A
Total program cost	N/A	$1,944.3	N/A
Program unit cost	N/A	N/A	N/A
Total quantities	N/A	20	N/A
Acquisition cycle time (months)	N/A	130	N/A

The latest cost data reflect only the funding planned for fiscal years 2011 through 2020 and not a cost to complete amount as the acquisition program baseline has not been approved.

The B-2 DMS-M program is expecting to enter system development in January 2016 with one critical technology fully mature and three critical technologies nearing full maturity. Consistent with best practices and statute, the program completed a preliminary design review prior to development start. The Air Force invested about 40 percent of its total expected DMS-M development funds during technology development, completing activities such as software coding and ordering some test hardware. However, risks remain in several areas including system integration. The Air Force expects to achieve initial operating capability in 2022. Test aircraft availability, test range scheduling, test data turnaround times, and contractor staffing may present challenges to meeting this schedule.

Attainment of Product Knowledge

Projected as of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• *Release at least 90 percent of design drawings*	
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
.... Information not available
Not applicable

B-2 DMS-M Program

Technology and Design Maturity

The DMS-M program expects to enter system development with one critical technology fully mature, the receiver-processor for bands 1-3, based on flight tests from another program that uses a similar system. Three other critical technologies are nearing full maturity, having been demonstrated in a relevant environment. When the program entered the technology development phase in 2011, the band 4 antenna, band-4 receiver-processer, and geo-location algorithm technologies were very immature with limited demonstrations completed at that time. Since then, the program office has worked with the operational users to refine requirements and better match them with the maturity of the technologies. As a result, B-2 DMS-M capabilities have been reduced, but the user has determined that it is an acceptable trade given the additional cost and time that would be needed to meet the more demanding requirements. While the band 4 receiver-processor technology has been demonstrated on other programs, the team that independently assessed the DMS-M program noted that it still poses a risk due to the aircraft's intended operating environment.

Consistent with best practices and statute, the program completed a preliminary design review prior to beginning system development. The Air Force invested almost 40 percent of its total expected DMS-M development funds during the technology development phase to reduce risk. Risk reduction activities completed during technology development included ordering flight test hardware and extensive software coding. Competitive prototyping was conducted for the band 4 antennas and some subsystems completed critical design reviews. The DMS-M contractor estimates that 80 to 90 percent of the software development is complete. Technical challenges remain as the program enters system development including, the installed antenna impact on the aircraft's low observable features, calibration of the DMS-M system with installed antenna data, and the completion of software development. The program office currently projects that two key performance parameters could be at risk, but it expects to mitigate these risks over the next 4 years.

Other Program Issues

Initial operational capability has been delayed from 2019 to 2022 and estimated costs have increased by $500 million since estimates made at the start of the technology development phase in 2011. Program officials attribute some of this delay to funding reductions that occurred from fiscal year 2013 to 2015. The program office has identified several initiatives that it hopes will lower costs by as much as $189 million. These include using different test ranges to improve test sortie rates and bounding the system development phase to 5 years by incentivizing the contractor to meet schedules. There are challenges that could impact the program's ability to meet schedules, including the availability of a single test aircraft, test range availability and data turnaround times, and contractor staffing.

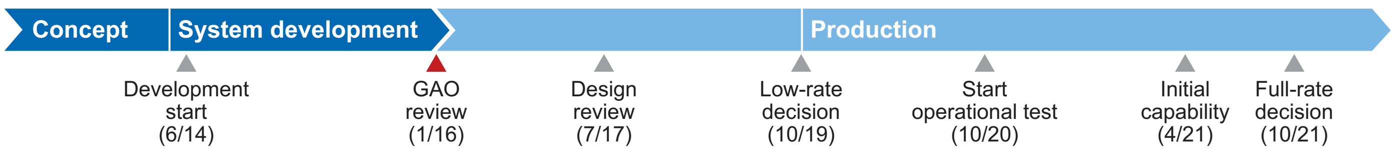
Program Office Comments

In commenting on a draft of this assessment, the program office provided comments, which were incorporated where deemed appropriate.

Combat Rescue Helicopter (CRH)

The Air Force's Combat Rescue Helicopter (CRH) is intended to recover personnel from hostile or denied territory as well as conduct humanitarian, civil search and rescue, disaster relief, and non-combatant evacuation missions. The CRH program is an effort to replace aging HH-60G Pave Hawk helicopters. The first effort to replace the HH-60G, the Combat Search and Rescue Replacement Vehicle (CSAR-X), was canceled in 2009 due to cost concerns stemming from technology development.

Source: ©2015 Sikorsky Aircraft Corporation. Used with permission for support of CRH.



Program Essentials

Prime contractor: Sikorsky Aircraft Corporation
Program office: Wright-Patterson AFB, OH
Funding needed to complete:
R&D: $1,757.9 million
Procurement: $6,542.6 million
Total funding: $8,326.7 million
Procurement quantity: 108

Program Performance (fiscal year 2016 dollars in millions)

	As of 06/2014	Latest 06/2015	Percent change
Research and development cost	$2,017.9	$2,018.5	0.0%
Procurement cost	$6,292.8	$6,542.6	4.0%
Total program cost	$8,335.1	$8,588.0	3.0%
Program unit cost	$74.421	$76.679	3.0%
Total quantities	112	112	0.0%
Acquisition cycle time (months)	75	82	9.3%

The CRH program began system development in June 2014 without identifying critical technologies and received waivers to multiple program certifications, including those for preliminary design review and technology risk reduction. DOD authorized these waivers as the program plans to modify an existing helicopter with mature subsystems and software. A technology readiness assessment is now underway and the program plans to conduct a preliminary design review in 2016. Program officials stated that testing to demonstrate the design will not occur prior to the critical design review. Although the CRH design is intended to limit risk, the program may not have gained sufficient knowledge to enter development. Not demonstrating the maturity of the design before critical design review perpetuates this risk and could lead to poor cost and schedule outcomes.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	▪▪▪▪
• Demonstrate all critical technologies in an operational environment	▪▪▪▪
• Complete preliminary design review	○
Product design is stable	
• *Release at least 90 percent of design drawings*	
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained ▪▪▪▪ Information not available
○ Knowledge not attained *Not applicable*

CRH Program

Technology Maturity

The CRH program began system development in June 2014 without identifying critical technologies. In transitioning from the canceled CSAR-X program, the Air Force reduced risk in the CRH design by lowering requirements and replacing the immature technologies identified in a technology readiness assessment completed for CSAR-X in 2006 with mature subsystems. The CRH program plans to modify and enhance an existing, flight proven helicopter–the UH-60M–by integrating mature subsystems and associated software. The planned modifications and enhancements include a mission computer and software, higher capacity electrical system, larger capacity main fuel tanks, armor for crew protection, and situational awareness enhancements. Based on this design proposal, DOD authorized the program to bypass technology development and enter the acquisition process at system development. DOD also waived several activities normally required to obtain program certification prior to the start of system development, such as conducting a preliminary design review, demonstration of technology in a relevant environment, and competitive prototyping. In 2015, the program conducted systems engineering reviews and reported that no significant risks or issues were identified. A technology readiness assessment for CRH is now being conducted by Air Force personnel independent of the program office in advance of a preliminary design review scheduled for April 2016. Program officials expect this assessment to confirm or rebut the Air Force's previous belief that the program has no critical technologies, which led to the program waiver decision.

Design and Production Maturity

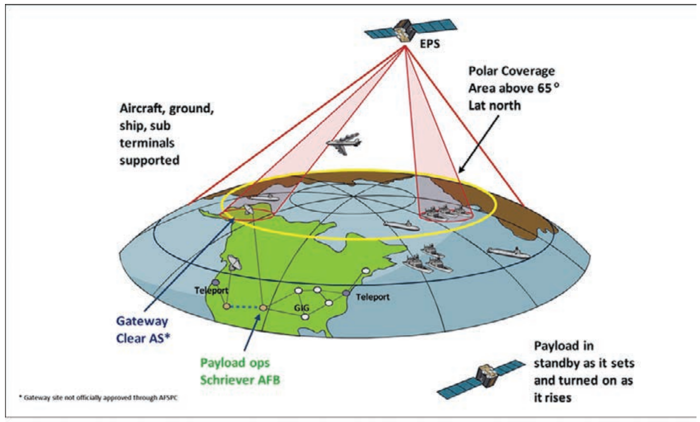
The program intends to monitor CRH design maturity by tracking items, such as the completion and approval of specifications, the number of design trades, and definitization of subcontract awards. Program officials stated that early prototype testing to demonstrate the design will not be needed before the critical design review, currently scheduled for July 2017, as CRH is a derivative of the operational HH-60M helicopter. However, the Air Force is integrating major new subsystems and software into this platform, and several risks related to the integration of these capabilities must be successfully mitigated. Currently the program plans to demonstrate an early system prototype in October 2018, 15 months after the scheduled assessment of the design's maturity at critical design review. Although the CRH acquisition strategy is intended to ensure the incorporation of mature technologies into an existing aircraft, by waiving competitive prototyping and the demonstration of technology in a relevant environment, and forgoing a preliminary design review prior to the start of system development, the program may not have gained sufficient knowledge to enter development with the least amount of risk. Not demonstrating the maturity of the design through testing with a fully integrated system-level prototype before critical design review perpetuates this risk. In our previous work, we have found acquisition programs which demonstrate technology and design maturity at appropriate points typically have better cost and schedule outcomes. Officials claim that sufficient amounts of development testing are planned to reduce these risks before the production start decision in 2019, including the testing of a production representative prototype.

Program Office Comments

In commenting on a draft of this assessment, the program office stated that an independent subject matter expert team is assessing the planned hardware and software design changes, and its final assessment is planned to be completed in January 2016. The program continually tracks risk under its risk management process. Based on a joint risk management board held in November 2015, the government and contractor did not identify any major risks, including risks related to technical maturity. Mitigation plans have been prepared for all risks. The next critical program milestone is the air vehicle preliminary design review in April 2016.

Enhanced Polar System (EPS)

The Air Force's Enhanced Polar System (EPS) is to provide next-generation protected extremely high frequency (EHF) satellite communications in the polar region. It will replace the current Interim Polar System and serve as a polar adjunct to the Advanced EHF (AEHF) system. EPS is to consist of three segments: two EHF payloads hosted on classified satellites, a Control and Planning Segment (CAPS), and a gateway to connect modified Navy Multiband Terminals to other communication systems.



Source: LinQuest Corporation.

Concept | **System development/Production**

Program initiation	Development start	Design review	Payload-1 on orbit	GAO review	Payload-2 on orbit	End operational test	Operational capability
(12/07)	(4/14)	(7/14)	(3/15)	(1/16)	(9/17)	(2/18)	(6/18)

Program Essentials

Prime contractor: Northrop Grumman
Program office: El Segundo, CA
Funding needed to complete:
R&D: $144.4 million
Procurement: $0.0 million
Total funding: $144.4 million
Procurement quantity: 0

Program Performance (fiscal year 2016 dollars in millions)

	As of 04/2014	Latest 12/2014	Percent change
Research and development cost	$1,431.0	$1,424.7	-0.4%
Procurement cost	$0.0	$0.0	0.0%
Total program cost	$1,431.0	$1,424.7	-0.4%
Program unit cost	$715.515	$712.373	-0.4%
Total quantities	2	2	0.0%
Acquisition cycle time (months)	126	126	0.0%

The EPS program formally entered system development in April 2014.The three segments of EPS–payloads, CAPS, and the gateway–are in various stages of completion. Although the EPS program's two EHF payloads are built and the first is on-orbit, funding constraints resulted in redesign and delays to CAPS and the gateway segments, in turn delaying initial operational capability by 2 years. CAPS completed software development in October 2015, and is proceeding with integration and testing. The gateway site installation is complete and testing was completed in December 2015. System inter-segment testing, which will test all three elements together, is expected to be completed in August 2016. Operational testing is scheduled for completion in 2018 and is the last significant schedule event, as there are no production related decisions for the program.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• *Release at least 90 percent of design drawings*	
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
.... Information not available
Not applicable

EPS Program

Technology and Design Maturity

The EPS program formally entered system development in April 2014. The Under Secretary of Defense for Acquisition, Technology, and Logistics directed the program to proceed to system development to synchronize the program's payload development schedule with the host satellite's production timeline. The program office for the host satellite awarded the payload development contract in July 2008, following an acquisition board equivalent to a system development decision. All three segments of the program will be completed under a development effort, and there are no production-related decisions for this program.

Both payloads are built. The first payload became available for on-orbit testing, which includes hardware functions and uplink and downlink capability, in March 2015. The second payload is integrated into the host satellite, is undergoing system-level testing, and is expected to be on orbit in the last quarter of fiscal year 2017. According to program officials, all EPS hardware development and critical technologies are associated with the payloads.

In contrast to payload development, the CAPS and the gateway segment were delayed as the program office used a design-to-cost approach to reduce CAPS and gateway requirements to the minimum capability needed due to funding constraints. The revised EPS acquisition strategy incorporating changes to CAPS and the gateway segment was approved in January 2012, and the program was approved to enter system development in April 2014.

The only development work remaining in the program is with CAPS. According to program officials, CAPS is primarily a software development effort and utilizes commercial off-the-shelf hardware. As such, the program uses software-related metrics, including software lines of code delivered, to track development progress. According to the program office, CAPS software development was completed in October 2015 and is in the process of software integration and testing. The gateway primarily involves integration of existing equipment and is considered low risk by the program office. Integration includes commercial off-the-shelf hardware such as routing and switching equipment, and terminals developed under other programs. The Navy's Space and Naval Warfare Systems Command Systems Center Pacific and MIT/Lincoln Laboratory are responsible for integrating, testing, and installing the gateway segment. Site installation for the gateway is complete, and the program office expects verification testing will be completed by the end of 2015. System level inter-segment interface testing of payload, gateway, and CAPS is scheduled for completion in August 2016.

Other Program Issues

In its comments on a draft of this assessment, the program office stated that, the 2012 revision of the acquisition strategy reduced program risk by reducing requirements for additional development. This decreased overall program cost by about $1 billion. However, the changes also delayed initial operational capability from fiscal year 2016 to 2018. According to program officials, the delay is not expected to result in a gap in coverage.

Program Office Comments

The EPS program officials provided technical comments, which were incorporated as appropriate.

Evolved Expendable Launch Vehicle (EELV)

The Air Force's EELV program provides spacelift support for DOD, national security, and other government missions. While the United Launch Alliance (ULA) is the only provider of launch vehicles and support functions currently under contract, Space Exploration Technologies (SpaceX) was certified to compete for national security launches with its Falcon 9 launch vehicle in May 2015. ULA provides launch services for EELV using two families of launch vehicles: Atlas V and Delta IV. We assessed the vehicle variants from both ULA and SpaceX.

Source: © 2012 United Launch Alliance.

Concept | System development | Production

- Program start (12/96)
- Development/ production start (6/98)
- Medium-lift first flight (8/02)
- Heavy-lift first flight (12/04)
- Initial capability (12/06)
- Milestone recertification (2/13)
- SpaceX certification (5/15)
- GAO review (1/16)

Program Essentials

Prime contractor: United Launch Services, LLC
Program office: El Segundo, CA
Funding needed to complete:
- R&D: $279.9 million
- Procurement: $34,734.2 million
- Total funding: $35,014.1 million
- Procurement quantity: 88

Program Performance (fiscal year 2016 dollars in millions)

	As of 10/1998	Latest 10/2014	Percent change
Research and development cost	$1,910.2	$3,008.0	57.5%
Procurement cost	$16,731.9	$57,489.0	243.6%
Total program cost	$18,642.1	$60,496.9	224.5%
Program unit cost	$102.995	$366.648	256.0%
Total quantities	181	165	-8.8%
Acquisition cycle time (months)	N/A	120	N/A

We assessed EELV technology as mature with 90 successful launches as of December 2015. EELV design and production maturity are not assessed using our best practices, but using an Aerospace Corporation measure that was developed for the program. Using that measure, eleven of the 14 EELV launch vehicle variants offered by ULA have demonstrated design maturity, as has SpaceX's Falcon 9. EELV is currently assessing options for an alternative to the Russian-made RD-180 engine used on the Atlas V vehicle, with industry expressing support for government investment in technology development and shared investment in launch service development, including rocket propulsion system development efforts. The program is also exploring options for an alternative to the Delta IV Medium launch vehicle, which ULA plans to discontinue in the fiscal year 2018 to 2019 timeframe.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
Demonstrate all critical technologies in a relevant environment	●
Demonstrate all critical technologies in an operational environment	●
Complete preliminary design review	
Product design is stable	
Release at least 90 percent of design drawings	
Test a system-level integrated prototype	
Manufacturing processes are mature	
Demonstrate critical processes are in control	
Demonstrate critical processes on a pilot production line	
Test a production-representative prototype	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

EELV Program

Technology, Design, and Production Maturity

Each of the EELV 14 variants offered by ULA, and the Falcon 9 from SpaceX, have flown at least once, demonstrating the viability of their technologies. For design and production maturity, launch vehicles are assessed using the 3/7 reliability rule developed by the Aerospace Corporation. According to this rule, once a variant is launched successfully three times, its design can be considered mature. Similarly, if a variant is successfully launched seven times, both the design and production process can be considered mature. Eleven of the ULA variants have achieved design maturity, and three have reached both design and production maturity. Some variants are used infrequently and may never reach design or production maturity. The Falcon 9 v1.1 has achieved both design and production maturity, but Air Force officials said SpaceX intends to use a new variant–the Falcon 9 Upgrade–for future EELV launch service competitions. This variant was successfully flown for the first time in December 2015. New variants introduce changes to the original design, which, until proven through multiple successful flights, pose potential cost and schedule risks.

In August 2014, the Air Force released a request for information on development of a domestic booster and launch system to replace the RD-180. It subsequently reported that industry responses indicate support both for investment in technical maturation at the propulsion system level as well as shared investment in development efforts with launch providers and competition for launch services–much like the original EELV program and the NASA Commercial Orbital Transportation Services, Cargo, and Commercial Crew programs.

Other Program Issues

ULA plans to phase out its Delta IV medium-lift class of vehicles in the fiscal year 2018 to 2019 timeframe and will introduce its new Vulcan launch vehicle currently in development with an initial capability expected in 2019. Unless a replacement for the RD-180 and Atlas V capability can be developed on this very aggressive timeline, this could result in a capability gap for some national security space launch missions in fiscal years 2020-2021, as the Falcon 9 does not have the capacity to launch all national security payloads. ULA has agreed to maintain the Delta IV heavy-lift class to meet national security space requirements until a replacement system is available. The Air Force and ULA are exploring continued use of the Delta IV medium-lift class. For example, they are looking at the possibility of preserving Delta IV tooling and expertise to reconstitute the production line, if needed.

According to Air Force officials, one possible remedy would be availability of SpaceX's proposed Falcon Heavy launch vehicle, which should be capable of meeting payload requirements in the EELV intermediate and heavy classes, currently being met by Atlas V and Delta IV Heavy. However, Air Force officials said SpaceX has not yet demonstrated the Falcon Heavy in flight, does not expect to do so until early 2016, and has only recently begun working with the Air Force toward vehicle certification.

In September 2015, the Air Force issued a request for proposal for EELV launch services, the first since SpaceX's Falcon 9 certification. Following the request, ULA announced that it did not intend to bid for the launch to put the second GPS III satellite into orbit, stating, among other things, that prohibitions on the use of the RD-180 restrict the company's use of the Atlas V. The National Defense Authorization Act (NDAA) for fiscal year 2015 prohibited, with certain exceptions, the award or renewal of a contract for the procurement of property or services for space launch activities under the EELV program if such contract carries out such activities using rocket engines designed or manufactured in the Russian Federation. The NDAA for fiscal year 2016 amended the exceptions to the prohibition. The 2016 DOD Appropriation Act stated that notwithstanding any other provision of law, award can be made to a launch service provider competing with any certified launch vehicle in its inventory regardless of the origin of the rocket engine.

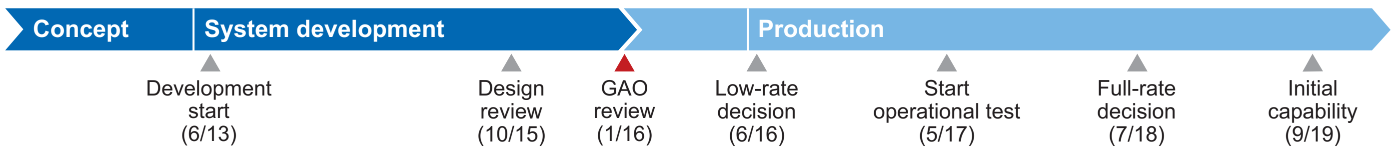
Program Office Comments

The Air Force provided technical comments, which were incorporated as appropriate.

F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)

The Air Force's F-22 Raptor is a stealthy air-to-air and air-to-ground fighter/attack aircraft. The Air Force established an F-22 modernization and improvement program in 2003 to add enhanced air-to-ground, information warfare, reconnaissance, and other capabilities, and to improve the reliability and maintainability of the aircraft. Increment 3.2B, the fourth increment of the modernization program was initially managed as part of the F-22 baseline program, but is now managed as a separate major defense acquisition program.

Source: U.S. Air Force.



Program Essentials

Prime contractor: Lockheed Martin
Program office: Wright-Patterson AFB, OH
Funding needed to complete:
R&D: $214.9 million
Procurement: $319.1 million
Total funding: $534.0 million
Procurement quantity: 143

Program Performance (fiscal year 2016 dollars in millions)

	As of 06/2013	Latest 07/2015	Percent change
Research and development cost	$1,254.2	$1,218.2	-2.9%
Procurement cost	$353.7	$347.1	-1.9%
Total program cost	$1,607.9	$1,565.3	-2.6%
Program unit cost	$10.578	$10.298	-2.6%
Total quantities	152	152	0.0%
Acquisition cycle time (months)	72	75	4.2%

Increment 3.2B completed its design review in October 2015, after a 3 month delay, with its one critical technology fully mature and its design stable and demonstrated with 98 percent of its drawings releasable. The one reported critical technology has been demonstrated in a realistic environment, and, according to program officials, flight testing will conclude in December 2015. The program is using an iterative software development process with seven releases of capability, up one from initial estimates. Further delays in fielding earlier F-22 modernization increments could have an effect on fielding of Increment 3.2B, as the increments build upon each other. Increment 3.2B received approval to begin system development as a separate major defense acquisition program in June 2013.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
.... Information not available
Not applicable

F-22 Inc 3.2B Mod Program

Technology and Design Maturity

The program's sole identified critical technology, a geolocation algorithm, is fully mature. It has been demonstrated in a realistic environment, and, according to program officials, will complete flight testing in December 2015. The program demonstrated its design prior to the October 2015 critical design review and 98 percent of system-level drawings are currently releasable. According to officials, the program intends to conduct demonstrations with an integrated, system-level prototype through December 2015. The critical design review was a culmination of multiple incremental critical design reviews, with the October 2015 review focused on software as the program had already completed hardware reviews.

According to a program official, initial flight testing of the software has already begun. The program is using an iterative software development process where six software releases had been planned. Due to interface issues, the program added an additional software release, for a total of seven. This software release is only for lab testing but added an additional month to the program's schedule as well as some cost, according to officials.

Other Program Issues

Program officials stated that all F-22 Increment 3.2B modifications will be completed by contractor field teams at bases and not in the depot, as this is a less costly approach. Depot-level maintenance refers to major maintenance and repairs, such as overhauling, upgrading, or rebuilding parts, assemblies, or subassemblies, which is usually performed at a facility known as a depot. Program officials noted that the schedule for fielding Increment 3.1 has been affected due to depot-level delays. Increment 3.2A is a software upgrade that requires Increment 3.1 hardware, and delays in the Increment 3.1 schedule have slowed the expected fielding of Increment 3.2A. Further delays may affect the time line for fielding future modernization increments, as the increments build on each other. Any further delays in fielding these earlier increments could affect fielding of Increment 3.2B.

Program Office Comments

In commenting on a draft of this assessment, the program office stated that in April 2015, the Under Secretary of Defense for Acquisition, Technology, and Logistics re-designated the F-22 Increment 3.2B program as an ACAT IC program and delegated milestone decision authority to the Air Force. To date, the Increment 3.2B program is proceeding as planned. Software lab testing was completed on the seventh agile software development release iteration in September 2015. The program also completed software lab testing on the first fully integrated developmental test software version (F1) and is conducting F1 developmental test flight test operations using the five Increment 3.2B modified flight test aircraft. The remaining four test aircraft to receive Increment 3.2B hardware modifications are on schedule to be completed by May 2016. In preparation for a low-rate production decision, the program is completing its manufacturing readiness assessment and has assessed the prime contractor and the suppliers manufacturing Increment 3.2B end item hardware.

Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)

The Air Force's FAB-T program plans to provide a family of satellite communications terminals for airborne and ground-based users to replace many program-unique terminals. Designed to work with current and future communications capabilities and technologies, FAB-T is expected to provide voice and data communications over military satellite networks for nuclear and conventional forces through ground command posts and E-6 and E-4 aircraft. A subprogram is expected to provide force element capabilities on B-2, B-52, and RC-135 aircraft.

Source: U.S. Air Force.

Concept | **System development** | **Production**

- Development start (9/02)
- New development award (9/12)
- Design review (6/13)
- Low-rate decision (9/15)
- GAO review (1/16)
- Complete operational test (7/17)
- Full-rate decision (11/17)
- Initial capability (12/19)

Program Essentials

Prime contractor: Raytheon
Program office: Bedford, MA
Funding needed to complete:
R&D: $218.8 million
Procurement: $1,378.6 million
Total funding: $1,597.4 million
Procurement quantity: 189

Program Performance (fiscal year 2016 dollars in millions)

	As of 12/2006	Latest 12/2014	Percent change
Research and development cost	$1,649.1	$2,718.9	64.9%
Procurement cost	$1,771.8	$1,589.3	-10.3%
Total program cost	$3,420.9	$4,308.3	25.9%
Program unit cost	$15.837	$16.634	19.9%
Total quantities	216	259	19.9%
Acquisition cycle time (months)	129	207	60.5%

The latest cost and quantity data do not reflect recent program decisions. A new acquisition program baseline has not yet been approved.

While the technology and design for 10 initial FAB-T units appear to be stable, testing remains for final configurations using new antennae and currently immature technologies. In September 2015, the Air Force received approval to begin low-rate production and expects to mature production processes after factory testing of initial units. However, the initial units will require retrofitting with new antennae. The program has not yet planned for developing and producing force element terminals needed to achieve FAB-T's full communications capabilities, but the Air Force expects to provide a plan by June 2016. Program delays to FAB-T prevent the full utilization of Advanced Extremely High Frequency Satellite capabilities. The Air Force expected approval of a revised cost and schedule baseline by the end of 2015, but it has not yet been approved.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	○
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	○
• Demonstrate critical processes on a pilot production line	●
• Test a production-representative prototype	○

● Knowledge attained
○ Knowledge not attained
.... Information not available
Not applicable

FAB-T Program

Technology and Design Maturity

According to the program office, the technologies and design used in the configuration for the first lot of low-rate production units are mature. However, this initial lot does not reflect the final configuration of the terminal, which will use a new antenna, and these initial units, while fully functional, will eventually need to be retrofitted. The new antenna includes five separate critical technologies, four of which are currently immature. Program officials estimated that the new antenna technologies will be mature by September 2016. The design for the final configuration is stable, and program officials said they expect only minor revisions or updates to the existing design as they complete testing.

Production Maturity

FAB-T received verbal approval to begin low-rate production in September 2015, followed by a formal acquisition decision in October 2015. The program expects to fully mature its production process following production and factory testing of its initial low-rate units. The program intends to purchase more than 60 percent of its total units during low-rate production. Generally, programs must provide a rationale if low-rate production quantities are going to exceed 10 percent of total quantities. Program officials explained that these units are required to demonstrate initial operational capability by the end of 2019.

Other Program Issues

In 2012, FAB-T's acquisition strategy was changed to offer two possible production paths–one providing both command post and force element terminals and the other only command post terminals. In July 2015, the Department of Defense separated the command post terminals and force element terminals into two sub-programs. Currently, only the command post terminals subprogram is in development and production, while the force element terminals are not funded in the 2016 President's budget submission. If not integrated with the B-2 and B-52 bomber platforms, FAB-T may not achieve its planned capabilities as some are based on the interaction of bomber aircraft with intelligence, surveillance, and reconnaissance aircraft and command post terminals. In October 2015, the Undersecretary of Defense for Acquisition, Technology, and Logistics instructed the Air Force to develop a strategy for achieving the force element terminal requirements by February 2016, and the Air Force requested an extension until June 2016.

FAB-T plans to communicate through the Advanced Extremely High Frequency network of satellites. Three of these satellites have already been launched, but FAB-T has yet to be fielded, resulting in underutilization of these costly satellite capabilities. By the time FAB-T achieves initial operating capability in 2019, one of these satellites will have been operating for nine years, over half of its projected operational lifetime.

The Air Force expected approval of a revised cost and schedule baseline by the end of 2015, based on a new independent cost estimate; however, it has not yet been approved. The new baseline will reflect the numerous program changes to the current baseline established in 2007.

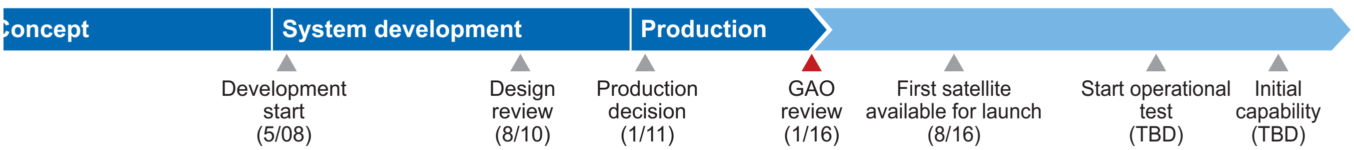
Program Office Comments

In commenting on a draft of this assessment, the program office stated that in September 2015, the program conducted a successful production decision, resulting in verbal approval by the milestone decision authority to purchase the first 10 of 53 low-rate initial production terminals. Production is underway with the first terminal delivery anticipated in December 2016. Development and testing is ongoing for the remaining antenna configurations to demonstrate maturity prior to commencing production of these configurations. The projected start of production of the final configurations was the third quarter of fiscal year 2016; however, the program office is now looking at an incremental release of new antenna configurations beginning in the fourth quarter of fiscal year 2016, with the final configuration beginning in the first quarter of fiscal year 2017. The program is on track to meet initial operational capability in December 2019.

Global Positioning System III (GPS III)

The Air Force's Global Positioning System (GPS) III program plans to develop and field a new generation of satellites to supplement and eventually replace GPS satellites currently in use. Other programs are developing the related ground system and user equipment. GPS III is intended to provide capabilities for a stronger military navigation signal to improve jamming resistance and a new civilian signal that will be interoperable with foreign satellite navigation systems.

Source: U.S. Air Force.



Program Essentials

Prime contractor: Lockheed Martin
Program office: El Segundo, CA
Funding needed to complete:
R&D: $224.4 million
Procurement: $235.7 million
Total funding: $460.1 million
Procurement quantity: 0

Program Performance (fiscal year 2016 dollars in millions)

	As of 05/2008	Latest 07/2015	Percent change
Research and development cost	$2,708.5	$3,180.1	17.4%
Procurement cost	$1,520.7	$1,737.4	14.3%
Total program cost	$4,229.2	$4,917.5	16.3%
Program unit cost	$528.644	$614.682	16.3%
Total quantities	8	8	0.0%
Acquisition cycle time (months)	N/A	N/A	N/A

We could not calculate acquisition cycle times for the first increment of the GPS III program because initial operational capability will not occur until satellites from a future increment are fielded.

The program currently reports all technologies as mature and the design as stable but manufacturing processes as not yet in control. The first GPS III satellite completed baseline thermal vacuum testing–a major system-level event for the program. GPS III is rebaselining its cost and schedule estimates due to delays in the availability for launch first reported in early 2014. Program officials stated that the new available for launch date is August 2016–almost two and a half years later than originally planned. These delays are accompanied by even more extensive delays on the related ground system–the Next Generation Operational Control System (OCX)–and even later delivery of military GPS user equipment program. Both are needed to provide all GPS III planned capabilities.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	○
• Demonstrate critical processes on a pilot production line	●
• Test a production-representative prototype	○

● Knowledge attained
○ Knowledge not attained
.... Information not available
Not applicable

GPS III Program

Technology Maturity

The program office reports that all eight GPS III critical technologies are fully mature. The program previously experienced design and manufacturing problems with the mission data unit, a key component of the navigation payload, which delayed the program by almost 2 years. The program office reported that those problems have been resolved and that verification of its design and manufacturing processes are complete.

Design and Production Maturity

The program office reports that the GPS III design is currently stable based on the number of design drawings released to manufacturing. To prove out production processes prior to integrating and testing the first space vehicle, the program tested a system-level integrated prototype that included all key subsystems and components, but less redundancy than the final configuration. A complete satellite was not tested prior to GPS III's production decision in 2011, but the program reported a level of manufacturing process maturity that indicated its processes were in control and production could begin. However, the program recently reported a lower level of maturity that indicates production processes are not yet fully in control. This level of maturity is high enough to meet DOD's standards for the start of production, but not those recommended by best practices.

Other Program Issues

In December 2015, the first GPS III space vehicle completed baseline thermal vacuum testing. This key test event validates satellite performance in a simulated space environment in order to demonstrate the satellite's performance under environmental extremes and to increase mission assurance.

Due to a delay to launch availability of over 2 years first reported in early 2014, the program is in the process of rebaselining costs and schedule. Program officials stated that the new available for launch date is August 2016–seven months later than GAO previously reported and almost two and a half years later than originally planned. Total acquisition costs in the new baseline will likely be higher and the quantity of satellites will change from 8 to 10. Approval of the new baseline is expected in 2016.

Although elements of the GPS III program, such as thermal vacuum testing, have experienced delays, the satellites' dependence on the much delayed OCX is a greater risk to constellation sustainment. GPS III satellites cannot be integrated into the constellation or achieve operational capability until OCX Block 1 is delivered, currently scheduled for July 2021, 6 years later than originally planned. As a result of these delays, several GPS III satellites may be available for launch before they are fully tested with OCX. However, the Air Force reported that it is taking steps to enable GPS III integration into the constellation by spring 2019. Moreover, although testing the satellites functionality is not dependent on new military GPS user equipment, timing of capability delivery for that program will further postpone–by about a decade–the warfighters ability to take advantage of newer GPS III satellite capabilities, such as improved resistance to jamming.

Program Office Comments

In commenting on a draft of this assessment, the program office stated that the first GPS III satellite is on track for an August 2016 available for launch date, and that significant confidence was gained in the contractor design and workmanship as a result of thermal vacuum testing. The program office also noted that the contractor demonstrated production line maturity and that vigilant monitoring for future problems will continue to mitigate delays. The next major test event for the first space vehicle will be electromagnetic interference testing in March 2016. Technical comments were provided by the program office, which were incorporated where deemed appropriate.

KC-46 Tanker Modernization Program (KC-46A)

The Air Force's KC-46 program plans to convert a commercial aircraft into an aerial refueling tanker for operations with Air Force, Navy, Marine Corps, and allied aircraft. The program is the first of three planned phases to replace the Air Force's aging aerial refueling tanker fleet. The KC-46 has been designed to improve on the KC-135's refueling capacity, efficiency, capabilities for cargo and aeromedical evacuation, and to integrate defensive systems.

Source: © 2011 Boeing. All rights reserved.

Concept	System development				Production			
Development start (2/11)	Critical design review (7/13)	KC-46 first flight (9/15)	GAO review (1/16)	Low-rate decision (4/16)	Start operational test (4/17)	Required assets available (8/17)	Full-rate decision (3/18)	

Program Essentials

Prime contractor: Boeing
Program office: Wright-Patterson AFB, OH
Funding needed to complete:
- R&D: $924.3 million
- Procurement: $32,317.9 million
- Total funding: $35,718.7 million
- Procurement quantity: 168

Program Performance (fiscal year 2016 dollars in millions)

	As of 02/2011	Latest 07/2015	Percent change
Research and development cost	$7,351.9	$6,757.3	-8.1%
Procurement cost	$35,699.9	$33,857.3	-5.2%
Total program cost	$47,021.3	$43,531.6	-7.4%
Program unit cost	$262.689	$243.193	-7.4%
Total quantities	179	179	0.0%
Acquisition cycle time (months)	78	78	0.0%

One of KC-46's three critical technologies is fully mature, and the other two are expected to be fully mature prior to the production decision in 2016. The design was considered stable at the July 2013 critical design review, but wiring and fuel system design changes were subsequently made. Demonstration of a system-level prototype–KC-46 first flight–was achieved in September 2015, more than 2 years after critical design review. Boeing is building four development aircraft and has begun fabricating additional production units. A key supplier is not delivering aerial refueling systems on time, which could affect the timely delivery of aircraft. According to the program office, it will continue to monitor and assess the maturity of production following Department of Defense guidance.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

KC-46A Program

Technology Maturity

The program office identified three critical technologies for KC-46, two software modules related to situational awareness and a three-dimensional display that allows the crew to monitor aerial refueling activities. Currently, one of these three critical technologies–a situational awareness software module–is fully mature. The other two technologies are nearing full maturity, having been tested in a laboratory. The program plans to fully mature all technologies through laboratory and flight testing, prior to the low-rate production decision currently scheduled for April 2016.

Design Maturity

At its critical design review, the program had released over 90 percent of its design drawings. Since that time, problems were discovered with the wiring of the commercial aircraft and the design of the aerial refueling system that led to revisions. Boeing is behind schedule in building the first four aircraft due to this redesign and late deliveries of components. A key supplier has experienced significant difficulty in manufacturing and completing qualification testing of the drogue refueling systems due, in part, to challenges complying with Federal Aviation Administration component qualification procedures. This adds risk to Boeing's ability to deliver low-rate production aircraft in August 2017.

As a result of these delays, first flight of an integrated KC-46 aircraft with military sub-systems to demonstrate design maturity slipped more than 8 months to late September 2015, about 26 months after critical design review.

Production Maturity

The program office and Boeing have taken several initial steps to capture necessary manufacturing knowledge. As of August 2015, the program office has completed manufacturing readiness assessments on all critical manufacturing processes. According to the program office, it will continue to monitor and assess the maturity of production following standards set in Department of Defense guidance. Due to redesigns, manufacturing processes are being conducted out of sequence on the four development aircraft currently in fabrication.

Other Program Issues

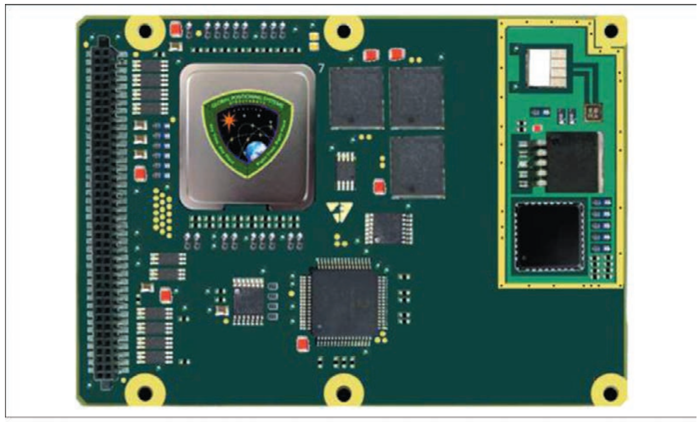
Boeing has experienced test failures with aerial refueling system components and test related delays, such as an accidental fuel contamination event that damaged the second development aircraft's fuel system. Boeing is re-baselining its schedule to account for these delays and has been working with the program office to restructure the program. The low-rate initial production decision is currently scheduled for April 2016. Boeing plans to complete roughly 60 hours of aerial refueling demonstrations over a 30-day period in support of this decision. Government test officials believe this pace is unrealistic based on historical data.

Program Office Comments

In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

Military GPS User Equipment (MGUE) Increment 1

The Air Force's MGUE program plans to develop GPS receivers compatible with the military's next-generation GPS signal, Military-Code. The modernized receivers are to provide U.S. forces with enhanced position, navigation, and time capabilities, while improving resistance to existing and emerging threats, such as jamming. The program consists of two increments. Increment 1, assessed here, leverages technologies from the Modernized User Equipment program to develop receivers for aviation, maritime, and ground platforms.



Source: U.S. Air Force.

Concept → **System development** → **Production**

- Program start (4/12)
- Preliminary design review (9/14)
- GAO review (1/16)
- Development start (9/16)
- Production decision (TBD)

Program Essentials

Prime contractor: L-3, Raytheon, Rockwell Collins International
Program Office: El Segundo, CA
Funding needed to complete:
R&D: $398.0 million
Procurement: $0.0 million
Total funding: $398.0 million
Procurement quantity: 0

Program Performance (fiscal year 2016 dollars in millions)

	As of	Latest 08/2015	Percent change
Research and development cost	N/A	$1,640.9	N/A
Procurement cost	N/A	$0.0	N/A
Total program cost	N/A	$1,640.9	N/A
Program unit cost	N/A	N/A	N/A
Total quantities	N/A	N/A	N/A
Acquisition cycle time (months)	N/A	N/A	N/A

The latest cost data reflect the funding provided for MGUE Increment 1 since program start and exclude expenditures made under the prior Modernized User Equipment Program.

MGUE is scheduled to enter development in September 2016 with three of its five critical technologies mature. In order to begin procuring MGUE receivers in fiscal year 2018, the Air Force eliminated the critical design review, stating that many design and risk assessments were completed earlier during design and test activities. DOD stated that conducting a design review, as recommended by GAO in September 2015, would delay the program by 6 to 12 months. However, the Army stated that the current prototypes do not meet all Army requirements, and DOD's test authority noted that the Air Force had overstated maturity. Integration testing–during which problems are likely to be found–will not be completed until 2019. Consequently, the services are unlikely to have sufficient knowledge to begin procuring MGUE receivers in 2018.

Attainment of Product Knowledge

Projected as of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• *Release at least 90 percent of design drawings*	
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

MGUE Increment 1 Program

Technology and Design Maturity

The MGUE Increment 1 program plans to enter system development with three of its five critical technologies–military-code acquisition engine, military-code cryptography, and selective availability anti-spoofing module functionality–mature and the remainder–anti-spoofing and anti-tamper–nearing maturity. These maturity levels were assessed during a November 2014 independent technology readiness assessment. The Director, Operational Test and Evaluation expressed concerns about one of the Air Force's test demonstrations and emphasized in a memorandum to the Undersecretary of Defense for Acquisition, Technology, and Logistics that the Air Force had overstated MGUE maturity, and that the demonstration had achieved more mixed results than the service indicated.

The program's acquisition strategy may limit insight into MGUE design. The latest approved strategy eliminated the critical design review as the Air Force states that MGUE design has been adequately demonstrated. Specifically, the Air Force stated that this review was unnecessary as, among other things, detailed design work and key development and design risks normally reviewed at critical design review were completed for MGUE's preliminary design review in September 2014. In addition, the Assistant Secretary of Defense for Acquisition stated in comments to GAO's September 2015 report on MGUE that conducting a critical design review would require MGUE contractors to halt development efforts and delay the program by 6 to 12 months, delaying the expedited fielding of MGUE receivers.

The program, however, carries design-related risks that would typically be addressed in a critical design review. For example, in an April 2015 assessment of the MGUE preliminary design review, the Office of the Undersecretary of Defense for Systems Engineering noted that the MGUE preliminary designs may not be rigorous enough to implement those designs beyond the initial test platforms from the military services. In addition, the Army has indicated there are power and thermal incompatibility issues between the MGUE ground receivers and Army platforms. Army and Navy officials noted that their respective services will need to conduct further work to develop MGUE to a production-ready status.

Production Maturity

The military services are unlikely to have the knowledge to begin MGUE procurement at the start of fiscal year 2018. The National Defense Authorization Act for fiscal year 2011 generally prohibits DOD from obligating or expending funds for GPS user equipment after fiscal year 2017 unless that equipment is capable of receiving military-code. The Secretary of Defense may waive this limitation under certain circumstances, or certain exceptions may apply. Program officials stated that the Undersecretary of Defense for Acquisition, Technology, and Logistics intends to delegate the MGUE production decision to the military services, and that the Air Force will continue to remain responsible for receiver certifications and software upgrades. MGUE integration testing with the services' lead platforms is scheduled to continue until late 2019. This phase of testing commonly reveals problems. In July 2015, the Army, Navy, and Marine Corps stated that, given the development and testing required to bring MGUE receivers to production-ready status, they cannot currently determine when MGUE will be ready for procurement.

Program Office Comments

In commenting on a draft of this assessment, the program office noted that the 2014 technology readiness assessment rated all five critical technologies as nearing maturity or higher. The program stated that MGUE will conduct full development testing, including lab and platform testing, on initial and final test articles for early risk reduction and to verify the functional baseline. The program also noted that, in parallel, the government will assess design security and compatibility, and the MGUE program will demonstrate manufacturing readiness on a pilot line and provide production representative articles for operational user evaluation. The program office also provided technical comments, which were incorporated as appropriate.

Next Generation Operational Control System (GPS OCX)

The Air Force's GPS OCX is to replace the current GPS satellite ground control system. GPS OCX will ensure reliable and secure delivery of position and timing information to military and civilian users. The Air Force plans to develop GPS OCX in blocks, with each block delivering upgrades as they become available. We assessed the initial three blocks–Block 0 for the checkout of new GPS satellites; Block 1 for satellite control and basic military signals; and Block 2 for fully modernized military signals and additional navigation signals.

Source: U.S. Air Force.

Concept		System development			Production			
Program start (2/07)	Development start (11/12)	GAO review (1/16)	Initial capability - Block 0 (9/17)	Production decision (7/18)	Start operational test (10/18)	Initial capability - Block 1 (TBD)	Initial capability - Block 2 (TBD)	

Program Essentials

Prime contractor: Raytheon
Program office: El Segundo, CA
Funding needed to complete:
R&D: $901.3 million
Procurement: $0.0 million
Total funding: $901.3 million
Procurement quantity: 0

Program Performance (fiscal year 2016 dollars in millions)

	As of 11/2012	Latest 07/2015	Percent change
Research and development cost	$3,552.5	$3,737.0	5.2%
Procurement cost	$0.0	$0.0	0.0%
Total program cost	$3,552.5	$3,737.0	5.2%
Program unit cost	$3,552.537	$3,736.999	5.2%
Total quantities	1	1	0.0%
Acquisition cycle time (months)	55	N/A	N/A

GPS OCX entered system development in November 2012, 2 years after its system development contract award, with all critical technologies nearing full maturity and after completing a preliminary design review. The program is primarily a software development effort, and according to program officials, has experienced significant development difficulties due to poor understanding of contract requirements, resulting in $1.1 billion in cost growth and a 4 year schedule delay so far. One effect of schedule delays is that future GPS III satellites cannot achieve operational capability until OCX Block 1 is delivered. The Air Force paused development in 2013 to identify and address problems in the program, but cost and schedule growth persist and are expected to continue. Unrealistic cost and schedule estimates limit visibility into and oversight of OCX system development.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• *Release at least 90 percent of design drawings*	
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

GPS OCX Program

Technology Maturity

GPS OCX entered system development in November 2012 with its 14 critical technologies nearing maturity and after an August 2011 preliminary design review. However, development work began more than 2 years prior when the program awarded the system development contract in February 2010. According to program officials, key requirements–especially for cybersecurity–were poorly understood by the Air Force and the contractor, which led to difficulty in developing capabilities and more complexity than initially planned. In particular, the OCX contractor states it did not fully understand the cybersecurity implementation requirements that help ensure DOD systems can resist and continue to operate during cyber-attacks. According to program officials, these requirements issues were mostly resolved in early 2015.

Design and Production Maturity

The OCX program does not track the metrics we use to measure design maturity, such as the number of releasable design drawings, as it is primarily a software development effort.

The OCX contractor failed to establish consistent software development environments, such as the computer infrastructure including hardware, operating systems, and databases, across the program causing high software defect rates. The program has not yet invested the time and resources to conduct assessments and determine if any systemic issues are causing these defect rates. We recently reported that the high defect rate may be attributable to the contractor's undisciplined processes, as noted by the OCX program office, independent review teams, and the Defense Contract Management Agency (DCMA).

Other Program Issues

OCX development contract costs have more than doubled–increasing by approximately $1.1 billion to $1.98 billion–and the program's schedule has been extended by 5 years from estimates established at contract award. The Air Force paused development in 2013 to identify and address problems in the program, but cost and schedule growth have persisted. Unless problems with software development are addressed, further cost and schedule growth is likely. According to DCMA officials, the program has a history of overly optimistic schedules. Further, the program assumed efficiencies which have not materialized due to staff turnover, process changes, and poor retention of lessons learned from past software development efforts. As a result, DOD may not have adequate insight into OCX system development.

New GPS III satellites cannot be integrated into the constellation or achieve operational capability until OCX Block 1 is delivered. We reported in September 2015 that an independent review of the program found Block 1 will likely be delivered in November 2020, which represents an additional year delay to the last official estimate. However, recent information suggests Block 1 delivery may be delayed by at least another year beyond that. As a result, it is likely that several GPS III satellites will be launched before they can be fully tested with OCX as needed. The Air Force plans to implement a GPS III contingency operations capability, which will allow for limited operational capability until OCX Block 1 is delivered.

Program Office Comments

In commenting on a draft of this assessment, DOD stated that the Air Force has realized a 3 year schedule delay since program inception and is currently re-baselining the OCX program, extending the schedule by an additional 24 months. This extension is based on poor performance by the contractor, and in accordance with guidance from the Under Secretary of Defense for Acquisition, Technology, and Logistics. Additionally, a new service cost position is currently under development. Technical comments were also provided by the program office, which were incorporated where deemed appropriate.

Small Diameter Bomb Increment II (SDB II)

The Air Force's Small Diameter Bomb Increment II (SDB II) is designed to provide attack capability against mobile targets in adverse weather from standoff range. It combines radar, infrared, and semiactive laser sensors in a tri-mode seeker to acquire, track, and engage targets. It uses airborne and ground data links to update target locations, as well as GPS and an inertial navigation system to ensure accuracy. SDB II will be integrated with F-15E, F/A-18E/F, and F-35 aircraft, among others.

Source: © 2009 Raytheon Company.

Concept | **System development** | **Production**

- Program start (5/06)
- Development start (7/10)
- Design review (1/11)
- Low-rate decision (6/15)
- GAO review (1/16)
- Initial capability F-15E (7/18)
- Full-rate decision (1/22)
- Initial capability JSF (4/22)

Program Essentials

Prime contractor: Raytheon Missile Systems
Program office: Eglin AFB, FL
Funding needed to complete:
R&D: $488.8 million
Procurement: $2,178.1 million
Total funding: $2,666.9 million
Procurement quantity: 16,856

Program Performance (fiscal year 2016 dollars in millions)

	As of 10/2010	Latest 09/2015	Percent change
Research and development cost	$1,764.6	$1,699.9	-3.7%
Procurement cost	$3,280.0	$2,407.8	-26.6%
Total program cost	$5,044.6	$4,107.7	-18.6%
Program unit cost	$0.294	$0.239	-18.6%
Total quantities	17,163	17,163	0.0%
Acquisition cycle time (months)	72	96	33.3%

SDB II entered production in June 2015 with all of its critical technologies mature and production processes that were in control, but with an unstable design. The program still has significant testing to complete, and any problems it discovers could result in further design changes. Since June 2015, SDB II has completed three successful flight tests, but one live fire flight test failed. The program was not able to identify a root cause for this failure and plans to resume flight tests in January 2016. The program successfully completed the first of two environmental qualification tests. The second test is scheduled for the second quarter of fiscal year 2016, and officials said it is a prerequisite for further production. The program reported an eight month delay in initial operational capability due to design issues, and delays with the F-35 program have extended low-rate production.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	●
• Demonstrate critical processes on a pilot production line	●
• Test a production-representative prototype	●

● Knowledge attained
○ Knowledge not attained
.... Information not available
Not applicable

SDB II Program

Technology and Design Maturity

The SDB II's four critical technologies–guidance and control, multi-mode seeker, net ready data link, and payload–are mature. They reached full maturity by the program's low-rate production decision in June 2015, almost 5 years after development start.

SDB II experienced design changes in 2015 and continues to experience test failures that could lead to further design changes. All of the program's design drawings have been released, but officials stated that the system will require design changes and drawings updates due to design issues discovered during qualification and flight testing. These design issues were responsible for approximately 45 percent of the program's schedule delays.

The SBD II program still has significant developmental testing to complete, and any problems it discovers could result in further design changes and costly retrofits. Following the low-rate production decision in June 2015, the program successfully completed two guided flight tests and one live fire flight test. A second live fire flight test hit its intended target, but the warhead did not detonate. The program was not able to identify a root cause for this failure, but did identify potential failure modes that could cause the fuze to not arm properly. The program implemented corrective actions for these failure modes and plans to conduct its next flight test in January 2016. The program also plans to conduct additional flight tests to further refine its understanding of the SBD II's three attack modes. This developmental testing includes 10 normal attack test events, six laser attack events, and six coordinate attack events, followed by a 28-shot government confidence test program in normal attack mode.

Production Maturity

In June 2015, SDB II program was approved to enter low-rate production after demonstrating its critical processes on a pilot production line, testing a production-representative prototype, and reporting all of its critical manufacturing processes as in control. The first production contract was for 144 units. Resolution of the issues discovered during testing may require manufacturing changes once the design changes have been incorporated.

Prior to SDB II's low-rate production decision it completed the first part of its corrosive atmosphere environmental test. Officials stated that this test simulates the bomb's exposure to various environmental conditions for an extended period outside of its protective container. This successful test followed a failed test in June 2014. The second part of this test is scheduled to be completed in the second quarter of fiscal year 2016, and officials stated that it is a prerequisite for the Lot 2 production contract. Officials added that the configuration of the first two production lots will be slightly different due to this environmental test. Officials stated that the additional environmental test is mainly to ensure that the asset will be safe to operate from Navy ships. The Navy does not plan to procure any units until Lot 4.

Other Program Issues

SDB II officials stated that due to design issues discovered during qualification and flight testing, the SDB II's initial operational capability date has slipped by 8 months to March 2018. Delays with the F-35 program have also caused the program to extend its low-rate production, which will now include around 59 percent of the total procurement.

Program Office Comments

In commenting on a draft of this assessment, program officials stated that software development, technical discoveries, and flight test failure investigation activities have delayed progress. The program office is actively engaged with the manufacturer regarding a disciplined approach to SDB II software development, reinvigorating quality, and concentrated focus on the work required to return to flight testing. SDB II remains event based and will execute tests when ready.

The SDB II multi-mode seeker continues to demonstrate excellent performance in guided flight testing and captive flight tests. The seekers ability to correctly classify targets (wheeled, tracked, boat) in challenging environments and weather was demonstrated on the guided flight tests conducted during 2015. To date the seeker has demonstrated target classification capability that exceeds 95 percent accuracy rate. This capability is unique to SDB II and provides the operator greater targeting flexibility and accuracy against moving targets operating in adverse environmental conditions.

Space Fence Ground-Based Radar System Increment 1

The Air Force's Space Fence Increment 1 program is developing a large ground-based radar intended to detect and track objects in low and medium Earth orbit and provide this information to a space surveillance network. Space Fence is designed to use high radio frequencies to detect and track more and smaller objects than previous systems. The Air Force awarded a contract for the development and production of the first radar site in June 2014, and included a second radar site as an option which, if exercised, will be a separate program.

Source: U.S. Air Force.

Concept | System development/Production

- Program start (3/09)
- Development start (5/14)
- Final development/ production contract (6/14)
- Design review (6/15)
- GAO review (1/16)
- Start operational test (6/18)
- Initial capability (10/18)

Program Essentials

Prime contractor: Lockheed Martin MST
Program office: Hanscom AFB, MA
Funding needed to complete:
- R&D: $495.6 million
- Procurement: $0.0 million
- Total funding: $495.6 million
- Procurement quantity: 0

Program Performance (fiscal year 2016 dollars in millions)

	As of 04/2014	Latest 10/2015	Percent change
Research and development cost	$1,614.3	$1,580.0	-2.1%
Procurement cost	$0.0	$0.0	0.0%
Total program cost	$1,614.3	$1,580.0	-2.1%
Program unit cost	$1,614.299	$1,579.994	-2.1%
Total quantities	1	1	0.0%
Acquisition cycle time (months)	124	115	-7.3%

Since our last assessment, the Space Fence program has fully matured all its critical technologies through demonstrations with a prototype array or modeling and simulation. The program completed its critical design review in June 2015 and has completed all of its design drawings but has yet to demonstrate a system-level integrated prototype. The program plans to verify the design through testing on a prototype with some production-representative elements beginning in 2016. To accommodate the projected increase in the volume of data generated by Space Fence, a new data processing system is being developed by the Air Force in a separate acquisition program. The Air Force will achieve initial capability when the first site becomes operational, but full capability will only be achieved once the second site is operational.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	○
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

Space Fence Inc 1 Program

Technology Maturity

A technology readiness assessment completed in February 2015 showed that all seven of the program's critical technologies are fully mature. This maturity was achieved through integration of a prototype array or through modeling and simulation. Most of the technologies provide the capabilities for transmitting and receiving radar signals from the large array planned for Space Fence. According to program officials, this array will be one of the largest phased array radars ever built and will be significantly larger in size, and generate significantly more data, than the system it replaces. An array this size presents multiple challenges, such as calibrating and managing multiple radar beams and processing the significantly increased volume of tracking data.

Design and Production Maturity

Space Fence completed its critical design review in June 2015 with 100 percent of its design drawings complete. The final radar design will be 15 percent smaller than the contractor had initially planned. Testing of the initial design showed better performance than expected, and the contractor found that it could achieve the Air Force's required performance with a smaller radar. The Air Force confirmed these findings by independently examining the test results. The program plans to verify the design through testing on a prototype with some production-representative elements beginning in 2016. This prototype will be approximately 10 percent of the size of the final radar, but will demonstrate up to 70 percent of the system requirements. According to the program, the testbed prototype is not a contract requirement; the contractor elected to build it as part of the development process.

Award of the development and production contract marked the start of production. Space Fence is tracking the maturity of two manufacturing processes for components of the transmit and receive modules critical to the radar's production. These processes have not been demonstrated as in control, as recommended by best practices, but are at the level of maturity required in the system development contract.

Other Program Issues

The first Space Fence site, or increment, is expected to meet the Air Force's requirements for initial operational capability, but full capability will only be achieved once a second site is operational. Development and production of the second radar site, which would be Space Fence Increment 2, is a contract option. According to the program office, the Air Force is currently analyzing space threats to determine how a potential second site would contribute to mitigating these threats. According to the Air Force, the option for the second site has to be exercised before the negotiated fixed price option for the second increment expires in August 2018.

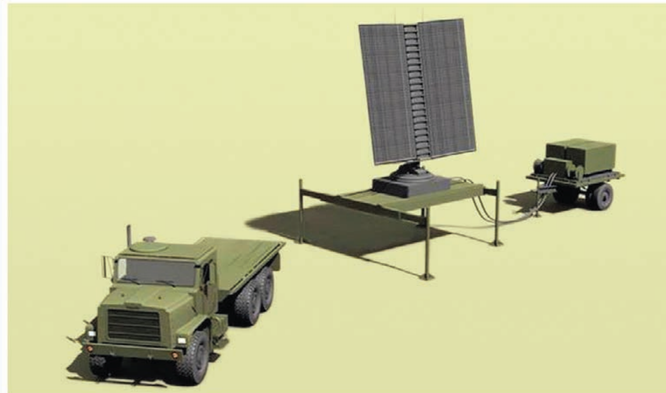
The Joint Space Operations Center (JSpOC) at Vandenberg AFB is acquiring a new data processing capability–JSpOC Mission System (JMS)–designed to enable processing of the increased volume of data expected from Space Fence. Currently, JMS is scheduled to become operational by December 2016, enabling input and processing of data from Space Fence to support its operational testing and initial capability. According to the Space Fence program office, the Space Fence and JMS programs have developed an interface control document to ensure compatibility and have planned joint test activities for the two systems.

Program Office Comments

In commenting on a draft of this assessment, the program office noted that manufacturing has begun for the production of line replaceable units for the integration test bed prototype. The prototype is undergoing installation and check-out of the radar transmit and receive hardware and software. The prototype should track its first resident space object in January and be fully operational in March 2016. In addition, the program office noted that significant construction progress has been made at the Space Fence Increment 1 site. The program also has ongoing integration risk reduction efforts between Space Fence and JMS. The contractor has connected to the JMS interface development environment and is performing weekly risk reduction testing. The second software build is complete and the third build is underway.

Three-Dimensional Expeditionary Long-Range Radar (3DELRR)

The Air Force's 3DELRR is being developed as a long-range, ground-based sensor for detecting, identifying, tracking, and reporting aerial targets, including highly maneuverable and low observable targets. The system intends to provide real-time data and support a range of operations in all types of weather and terrain. It will replace the Air Force's AN/TPS-75 radar systems, which is experiencing maintainability and sustainability issues.



Source: U.S. Air Force.

Concept | System development | Production

- Program start (5/09)
- Development start (10/14)
- GAO review (1/16)
- Design review (8/16)
- Low-rate decision (10/19)
- End operational test (9/20)
- Initial capability (12/21)

Program Essentials

Prime contractor: TBD
Program office: Hanscom Air Force Base, MA
Funding needed FY 2016 to FY 2020
- R&D: $178.7 million
- Procurement: $373.3 million
- Total funding: $552.1 million
- Procurement quantity: 11

Program Performance (fiscal year 2016 dollars in millions)

	As of	Latest 07/2015	Percent change
Research and development cost	N/A	$398.9	N/A
Procurement cost	N/A	$983.0	N/A
Total program cost	N/A	$1,381.9	N/A
Program unit cost	N/A	$39.483	N/A
Total quantities	N/A	35	N/A
Acquisition cycle time (months)	N/A	151	N/A

3DELRR entered system development in October 2014 with all of its critical technologies nearing full maturity and awarded a system development contract the following month. However, bid protests delayed the start of development work, and, as a result of issues raised by these protests, the Air Force re-opened the competition and plans to award a new system development contract in the second quarter of fiscal year 2016. Prior to system development start, the program took steps to reduce technical risk and program costs by conducting system-level competitive prototyping and analyzing the tradeoffs between costs and requirements. The 3DELRR program's remaining development risks may vary to some extent based on the contractor design selected for system development, although software integration will be a risk regardless of the contractor.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• *Release at least 90 percent of design drawings*	
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

3DELRR Program

Technology and Design Maturity

The 3DELRR program entered system development in October 2014 with all of its critical technologies approaching full maturity. The program plans to fully mature its critical technologies through the system development phase by demonstrating them in a realistic environment. According to program officials, the critical technologies will vary based on the contractor selected for system development.

While the 3DELRR program's specific development risks may vary to some extent based on the design of the contractor selected for system development, the program is tracking a number of overall development risks. For example, the 3DELRR's planned design is software-intensive, and software development was identified by program officials as a risk because, if not performed adequately, subsequent integration of hardware, software, and firmware could be delayed, resulting in additional cost. Program officials also stated that integrating the extensive amount of re-used software code contributed to the level of risk, but noted that each contractor is planning to mature and test software prior to installation and integration into the system. In addition, 3DELRR is expected to use a new semiconductor technology, which could pose cost or schedule risks. Specifically, the system is expected to use gallium nitride-based modules for the individual radiating elements key to transmitting and receiving electromagnetic signals, rather than the legacy gallium arsenide transmit/receive modules. While the use of gallium nitride may present some risks for the program, as long-term reliability and performance of this material are unknown and could affect radar sensitivity and power requirements, it has the potential to provide higher efficiency with lower power and cooling demands than legacy semiconductor technology.

Prior to the start of system development, the 3DELRR program conducted a number of risk reduction efforts in the technology development phase. For example, the program conducted system-level competitive prototyping, held preliminary design reviews with multiple contractors, and conducted capability demonstrations. According to program officials, these risk reduction efforts allowed the program to mature critical technologies, refine technical requirements and cost estimates, and assess manufacturing readiness.

Other Program Issues

Performance of the system development contract awarded to Raytheon in October 2014 was suspended as a result of bid protests by Lockheed Martin and Northrop Grumman. In January 2015, GAO dismissed the protests when the agency agreed to take corrective actions to address the issues raised in these protests. Program officials stated that the program re-entered source selection in May 2015, and they plan to award a new system development contract in the second quarter of fiscal year 2016.

Program Office Comments

The program office concurred with this assessment and provided technical comments, which were incorporated where appropriate.

Advanced Pilot Training (APT)

The Air Force's Advanced Pilot Training (APT) program is being developed to replace the T-38C aircraft and associated ground based training system currently used to meet the Air Force's advanced fighter pilot training needs. The APT will close training gaps which the T-38 cannot fully address with the introduction of the 4th and 5th generation fighter aircraft.

Source: U.S. Air Force.

Current Status

In October 2009, the Air Force identified a gap in its aircraft training beginning in 2018. In May 2010, the Under Secretary of Defense for Acquisition, Technology, and Logistics approved the Air Force's plans to conduct an analysis of alternatives. In June 2011, the analysis of alternatives was recommended that the existing training aircraft, the T-38, be replaced because a modification program would not be cost effective, address all the identified capability gaps, and would leave the USAF with aging airframes. The Air Force plans to release a request for proposals in the fourth quarter of fiscal year 2016 and award a fixed-price development/production contract in 2017. According to the Air Force, all required technology elements have mature solutions. In October 2015, the Joint Requirements Oversight Council approved the Capability Development Document for the APT. The Air Force has requested waivers for some of the mandatory certifications required prior to the start of system development, as the program does not plan to conduct a preliminary design review or pursue competitive prototyping before milestone B. According to program officials, all technical risks are low and all systems will have completed substantial flight tests prior to proposal submittals. Each offeror will be expected to present, as part of their proposal, actual flight test data that their aircraft performance parameters are being met. In our previous work, we have found that acquisition programs that successfully complete a preliminary design review prior to starting system development typically have better costs and schedule outcomes. Initial operational capability for the APT is currently expected in the fourth quarter of fiscal year 2024. The APT program does not have an approved acquisition program budget (APB) at this time; therefore, the estimated development cost shown below was obtained from the fiscal year 2016 President's Budget Request.

Estimated Program Cost and Quantity (fiscal year 2016 dollars):
Total program: TBD
Research and development (fiscal years 2015-2020): $600.4 million
Procurement: TBD
Quantity: TBD

Next Major Program Event: Development request for proposal release decision, fourth quarter fiscal year 2016

Program Office Comments: According to the program office, the proposed acquisition strategy was approved at an Acquisition Strategy Panel in July 2015. The program continues to gather pre-solicitation information from industry to refine the request for proposals (RFP). The APT program expects to release an RFP in late fiscal year 2016 with contract award and milestone B expected in late fiscal year 2017.

F-15 Eagle Passive / Active Warning and Survivability System (F-15 EPAWSS)

The Air Force's F-15 EPAWSS program plans to upgrade the electronic warfare system on fielded F-15 aircraft. The Air Force will use an incremental approach to deliver survivability improvements that include enhancing the F-15's ability to detect, identify, locate, deny, degrade, disrupt, and defeat air and ground threat systems. These improvements will enable operations in current and future threat environments and allow the F-15 fleet to remain viable into the 2040 timeframe. We assessed the first of two planned increments.

Source: U.S. Air Force.

Current Status

In August 2015, the Under Secretary of Defense for Acquisition, Technology, and Logistics approved the program's entry into technology development with system development scheduled to begin in August 2016. The program's request to waive competitive prototyping requirements prior to system development was approved in February 2015. A preliminary design review is currently planned for July 2016. The Air Force is taking an incremental acquisition approach to EPAWSS. The first increment replaces the F-15's existing, internal electronic warfare system. The second increment, contingent upon funding availability, adds a new towed decoy and associated countermeasures. The Air Force awarded a technology development contract to Boeing in September 2015. Under this contract, Boeing will have primary responsibility for system integration and has subcontract the development of the electronic warfare subsystem to a vendor that Boeing competitively selected in May 2015.

The Air Force plans to leverage non-developmental electronic warfare technologies and components currently used in other military aircraft to create a new electronic warfare system capable of protecting the F-15 against advanced enemy threats. However, the Air Force identified the digital receiver technology–both hardware and associated software–as a critical technology that the program does not expect to fully mature prior to the start of system development. According to program officials, software development and integration of the electronic warfare system with all other on-board and off-board systems are risk areas that could affect the Air Force's ability to have the required number of assets ready in time for the projected initial operational capability in 2021.

Estimated Program Cost and Quantity (fiscal year 2016 dollars):
Total program: $4,212.1 million
Research and development: $828.0 million
Procurement: $3,384.1 million
Quantity: 10 (development), 403 (procurement)

Next Major Program Event: Preliminary design review, July 2016

Program Office Comments: According to Air Force officials, the program is implementing a strategy to leverage mature non-developmental components as a key element of the program's efforts to drive positive schedule, affordability and risk outcomes. The program plans to demonstrate digital receiver critical technology prior to entry into system development.

Joint Surveillance Target Attack Radar System Recapitalization (JSTARS Recap)

The JSTARS aircraft is a manned airborne Battle Management Command and Control (BMC2) system providing near real-time surveillance and targeting information on moving and stationary ground targets. The Air Force's JSTARS Recap program is an effort to replace aging, legacy JSTARS aircraft initially fielded in the early 1990s. The JSTARS Recap acquisition program seeks to greatly reduce aircraft operating and sustainment costs, replace and improve JSTARS functionality, and minimize development and integration costs.

Source: U.S. Air Force.

Current Status

The JSTARS Recap program completed its materiel development decision in May 2015 and received following a seven-month material solution analysis phase, the program was granted a milestone A decision by the Under Secretary of Defense, Acquisition, Technology, and Logistics on December 10, 2015. The program intends to use an in-production, commercial-derivative aircraft integrated with a sophisticated surface search radar, BMC2, and broad-spectrum communication subsystems. The program also plans to deliver an adaptable, open architecture solution to reduce future upgrade costs and increase competition across the JSTARS Recap lifecycle. In August 2015, three firm-fixed price pre-engineering and manufacturing development contracts were awarded to Lockheed Martin, Northrop Grumman, and Boeing. According to the program, each of these contracts includes a provision for conducting a system requirements review as well as options for conducting system functional reviews, system-level preliminary design reviews, and building subsystem prototype demonstrators of the BMC2, radar, and communication subsystems. These subsystems are considered high risk due to systems integration challenges. According to a program official, JSTARS Recap exercised the options in December 2015 and is moving toward preliminary design reviews and subsystem prototype demonstrations in the spring/summer of 2016. The program has not identified any immature technologies and stated that all major subsystem hardware, and the majority of the BMC2 software, currently exist and are fielded. These subsystems have not, however, been integrated together into a single aircraft-based system. The program plans to conduct system-level preliminary design reviews with each contractor prior to selecting a single contractor and then starting development, a change from last year's assessment. Initial operational capability for JSTARS Recap is expected in the fourth quarter of fiscal year 2023.

Estimated Total Program Cost (fiscal year 2016 dollars):
Total program: $6,486.35 million
Research and development: $2,422.38 million
Procurement: $4,063.97 million
Quantity: 17

Next Major Program Event: Request for proposal decision review, September 2016

Program Office Comments: In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

Presidential Aircraft Recapitalization (PAR)

The PAR program plans to replace the current VC-25A fleet with a new fleet of aircraft to support the President of the United States as Head of State, Chief Executive, and Commander in Chief. The PAR aircraft will be a four engine wide-body, commercial derivative aircraft, uniquely modified to provide the President, staff, and guests with safe and reliable air transportation with the equivalent level of security and communications capability available in the White House.

Source: U.S. Air Force.

Current Status

The PAR program acquisition strategy was approved in September 2015 after several years of analysis related to risk reduction, requirements, sustainment, and technology and manufacturing maturity. According to officials, the milestone decision authority approved the PAR program to release a request for proposal to Boeing for design and risk reduction studies. The contract award for this effort is planned for January 2016. The program will seek a waiver from the requirement to conduct competitive prototyping before entering system development and to award a sole-source contract to Boeing for two 747-8 aircraft, which will then be modified to meet required capabilities with existing technologies. Program officials stated that they will participate in Boeing supplier selections for the subsystems and intend to acquire data rights to enable competition to the maximum extent practicable for future modifications and sustainment activities. Program officials acknowledge risks associated with the integration of these technologies but stated that the majority of the mission-related systems required have worked together before on different platforms, and many of these systems have legacy or related equivalents on the current VC-25A fleet. The two aircraft will be modified and tested in a phased approach. Once development is completed, the aircraft will be delivered as fully capable to support presidential missions, currently planned for fiscal year 2024.

Estimated Program Cost and Quantity (fiscal year 2016 dollars):
Total program (fiscal years 2010-2020): $3,210.6 million
Research and development (fiscal years 2010-2020): $1,987.1 million
Procurement (fiscal years 2017-2020): $282.2million
Quantity: 2

Next Major Program Event: Engineering manufacturing and development request for proposal release decision, July 2016

Program Office Comments: In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated as appropriate.

Weather System Follow-on (WSF)

The Air Force's Weather System Follow-on (WSF) is expected to be DOD's future weather satellite system. The WSF program is to be comprised of a group of systems to provide timely, reliable remote sensing capabilities that will make global environmental observations of atmospheric, terrestrial, oceanographic, and solar-geophysical conditions, and meet other requirements validated by the Joint Requirements Oversight Council.

Source: U.S. Air Force.

Current Status

Following two program cancellations, WSF is the third effort to provide space-based meteorological and oceanographic sensing capabilities to replace the current Defense Meteorological Satellite Program. As currently envisioned, WSF is to satisfy 3 of 11 necessary capability requirements as determined by a Space Based Environmental Monitoring Analysis of Alternatives completed in October 2013. The three capability requirements are to address ocean surface vector winds, tropical cyclone intensity, and low earth orbit energetic charged particle characterization, and are to be completed in two phases. According to officials, Phase 1 is to be a technology demonstration and is expected to use a currently available microwave payload to partially address ocean surface vector winds and tropical cyclone intensity. The Air Force, through its Operationally Responsive Space Office, will accelerate the acquisition process for Phase 1. The technology demonstration is expected to launch in late 2017 or early 2018. Phase 2, according to officials, is the WSF objective system.

The objective system will use microwave sensor technology and is envisioned as a single polar-orbiting satellite. DOD officials expect to launch the satellite in 2022 and to acquire a replacement satellite every 5 to 7 years. The program office expects to submit the acquisition strategy to the Office of the Undersecretary of Defense for Acquisition, Technology, and Logistics in January 2016. According to program officials, DOD is reviewing the remaining capability gaps focusing on the Joint Requirements Oversight Council's validated highest priority needs–cloud characterization and theater weather imagery.

The program plans to enter development with five of the six critical technologies-electronic polarization basis rotation, digital polarimetric receiver, digital back-end, internal calibration, and radio frequency interference mitigation-nearing maturity. The final technology–the bearing and power transfer assembly–is expected to be mature at development start.

Estimated Program Cost and Quantity (fiscal year 2016 dollars):
Total program: TBD
Research and development (fiscal years 2012-2020): $750.4 million
Procurement: TBD
Quantity: TBD

Next Major Program Event: System development start, TBD

Program Office Comments: The WSF program officials provided technical comments, which were incorporated as appropriate.

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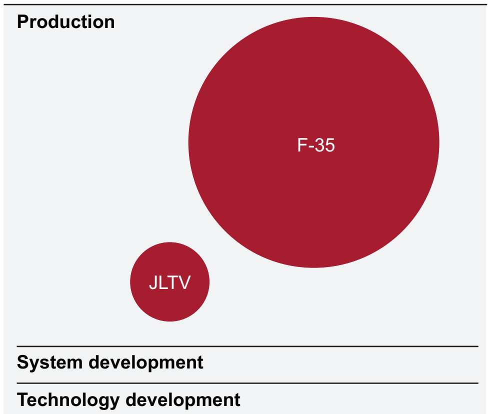
Joint DOD-wide Programs Summary

We performed in-depth assessments on two of the three “joint” or DOD-wide major defense acquisition programs in the current portfolio—the F-35 Joint Strike Fighter or Lighting II program and Joint Light Tactical Vehicle. These two programs currently estimate a need of more than $253 billion in funding to complete their acquisition. We determined cost and schedule change from first full estimates for both programs, and together they have experienced more than $110 billion in cost growth and average schedule delays of approximately 40 months. All of the cost growth is attributable to the F-35, and over 70 percent of the growth occurred more than 5 years ago. Of these two programs, the F-35 has completed all the activities associated with applicable knowledge-based best practices we assess but did so more than 7 years after its production start.

Acquisition Phase and Size of the Two Programs Assessed

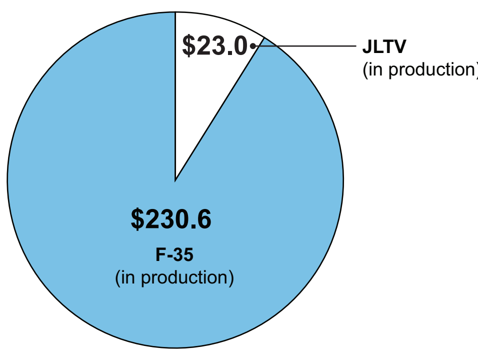


- Cost growth of more than 15 percent and/or schedule delays of more than 6 months
- Cost growth of 15 percent or less and schedule delays of 6 months or less
- No first full estimate available

Note: Bubble size is based on each program's currently estimated future funding needed.

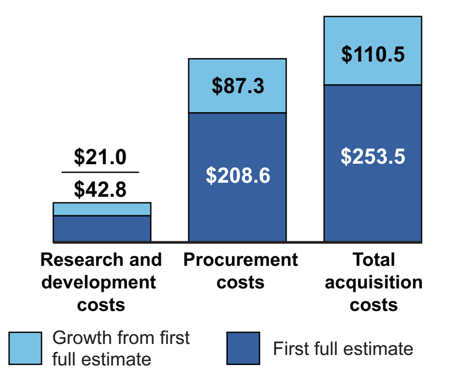
Currently Estimated Acquisition Cost for the Two Programs Assessed

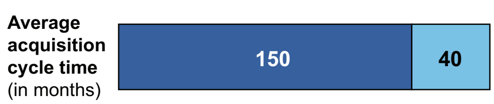
Fiscal year 2016 dollars in billions



Cost and Schedule Growth on Two Programs in the Current Portfolio

Fiscal year 2016 dollars in billions





Note: In addition to research and development and procurement costs, total acquisition cost includes acquisition related operations and maintenance and system-specific military construction costs.

Summary of Knowledge Attained to Date for Programs Beyond System Development Start

Program common name	Knowledge Point (KP) 1 Resources and requirements match	Knowledge Point 2 Product design is stable	Knowledge Point 3 Manufacturing processes are mature
F-35	●	●	●
JLTV	●	- - -	○

- ● All applicable knowledge practices were completed
- ○ One or more applicable knowledge practices were not completed
- ■ All knowledge practices were not applicable
- - - - Information not available for one or more knowledge practice

Source: GAO analysis of DOD data. | GAO-16-329SP

Joint DOD-wide Program Assessments

F-35 Lightning II Program (F-35)

DOD's F-35 program is developing a family of stealthy, strike fighter aircraft for the Navy, Air Force, Marine Corps, and U.S. allies, with the goal of maximizing commonality to minimize life-cycle costs. The carrier-suitable variant will complement the Navy F/A-18E/F. The Air Force variant is expected to replace the air-to-ground attack capabilities of the F-16 and A-10, and complement the F-22A. The short take-off and vertical landing (STOVL) variant is expected to replace the Marine Corps' F/A-18 and AV-8B aircraft.

Source: © Lockheed Martin.

Concept | System development | Production

- Program start (11/96)
- Development start (10/01)
- Design review (2/06 & 6/07)
- Production decision (6/07)
- Milestone recertification (3/12)
- USMC initial capability (7/15)
- GAO review (1/16)
- USAF initial capability (8/16)
- Start operational test (12/17)
- USN initial capability (8/18)

Program Essentials

Prime contractor: Lockheed Martin, Pratt and Whitney
Program office: Arlington, VA
Funding needed to complete:
R&D: $2,915.6 million
Procurement: $225,107.1 million
Total funding: $230,649.6 million
Procurement quantity: 2,226

Program Performance (fiscal year 2016 dollars in millions)

	As of 10/2001	Latest 12/2014	Percent change
Research and development cost	$41,817.7	$62,882.7	50.4%
Procurement cost	$185,525.6	$272,943.7	47.1%
Total program cost	$229,285.3	$339,996.9	48.3%
Program unit cost	$80.002	$138.379	73.0%
Total quantities	2,866	2,457	-14.3%
Acquisition cycle time (months)	175	237	35.4%

All of the program's critical technologies are now considered fully mature. One former critical technology, which had not been fully matured, has now been deferred to follow-on development. The next-generation helmet has completed initial testing and is being delivered to operators. Developmental testing is progressing, but, with the most complex testing remaining, more design changes are likely. Although the aircraft designs were not stable at their critical design reviews in 2006 and 2007, all baseline engineering drawings have since been released. Manufacturing efficiency is steady, and processes are considered in control. The program is planning a Block 4 upgrade to address capability deferrals, upgrade existing capabilities, and introduce additional weapons.

Attainment of Product Knowledge

As of January 2016	
Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	●
• Demonstrate critical processes on a pilot production line	●
• Test a production-representative prototype	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
Not applicable

F-35 Program

Technology and Design Maturity

All of the program's critical technologies are considered fully mature. One technology previously identified as critical and not fully matured, the prognostics and health management system a part of the Autonomic Logistics Information System (ALIS) and critical to fleet operations, has been deferred to follow-on development. In addition, the prognostic system specific to the engine has yet to be incorporated into ALIS. The program has completed initial testing of the next-generation helmet, which is expected to enhance night vision and optical performance, and it is currently being delivered to operators.

Although the aircraft designs were not stable at their critical design reviews in 2006 and 2007, all baseline engineering drawings have since been released. The program continues to test the aircraft and introduce design changes to address deficiencies discovered in testing concurrent with production. Design changes to fix issues with the bulkhead, engine, and arresting hook have been identified and planned for introduction into production. Although the total number of design changes generally continues to fall, with the most complex developmental testing remaining, the program faces the risk of further design changes.

Production Maturity

Aircraft manufacturing deliveries remain steady, and the contractor has delivered 154 aircraft as of December 2015. Since the start of production, the contractor's production processes have continued to mature, and program officials stated that they are now at a manufacturing readiness level that indicates they are in control. To continue making improvements and to increase quality, the contractor tracks statistical process control data and other quality indicators. Production part shortages remain a risk as suppliers will face additional pressures of balancing an increased production rate and simultaneously sustaining a growing operational fleet.

Other Program Issues

In July 2015, the Marine Corps declared initial operational capability with all but eight of the capabilities expected including capabilities centered on sensor fusion, electronic warfare, and communication. Marine Corps officials stated that these shortcomings do not interfere with their mission set. Program officials also stated that these capabilities will be available for the initial operational capability of the Air Force and Navy.

In August 2015, the Under Secretary of Defense for Acquisition, Technology, and Logistics approved the program's plan for follow-on development, beginning with Block 4, as part of the F-35's current baseline development program. Block 4 is expected to consist of four increments, alternating from primarily software in the first and third increments to hardware and software upgrades in the second and fourth increments. Program officials stated that Block 4 is expected to enhance capabilities and introduce new weapons. Block 4 will also incorporate capabilities and technologies that have been deferred from the baseline program, such as the prognostics health management downlink capability. The program estimates that Block 4 development will take about 10 years to complete.

Program Office Comments

In addition to providing technical comments, the program office noted that it appreciates GAO's reviews in assisting the program by identifying areas for improvement. According to the program office, the F-35 program is executing well across the entire spectrum of acquisition, to include development, flight test, production, fielding and base stand-up, sustainment of fielded aircraft, and building a global sustainment enterprise. The program is at a pivot point where it is moving from slow and steady progress to a rapidly growing and accelerating program. This transition is not without risks and challenges. The completion of mission systems software development, ALIS development, and fuel system and ejection seat deficiencies are the most prominent, current technical risks. The ability to standup four separate reprogramming labs, and our ability to complete all weapons envelope testing for Block 3F, and start operational test on time, constitute major schedule risks. The program remains confident that we will be able to deliver the full F-35 capability as promised.

Joint Light Tactical Vehicle (JLTV)

The Army and Marine Corps' JLTV is a family of vehicles being developed to replace the High Mobility Multipurpose Wheeled Vehicle (HMMWV) for some missions. The JLTV is expected to provide protection for passengers against current and future battlefield threats, increased payload capacity, and improved automotive performance over the up-armored HMMWV. It must also be transportable by air and ship. Two- and four-seat variants are planned with multiple mission configurations.

Source: JPO JLTV EMD Industry Contractors (Oshkosh Corp., AM General & Lockheed Martin).

Concept		System development		Production				
Program start (12/07)	Development start (8/12)	Design review (1/13)	Low-rate decision (8/15)	GAO review (1/16)	Begin operational test (2/18)	Full-rate decision (12/18)	Initial capability (12/19)	

Program Essentials

Prime contractor: AM General, Lockheed Martin, Oshkosh
Program office: Harrison Township, MI
Funding needed to complete:
R&D: $210.8 million
Procurement: $22,793.6 million
Total funding: $23,004.4 million
Procurement quantity: 54,408

Program Performance (fiscal year 2016 dollars in millions)

	As of 10/2012	Latest 06/2015	Percent change
Research and development cost	$1,021.3	$993.3	-2.7%
Procurement cost	$23,118.2	$22,962.7	-0.7%
Total program cost	$24,177.7	$23,956.1	-0.9%
Program unit cost	$0.442	$0.438	-0.9%
Total quantities	54,730	54,718	-0.0%
Acquisition cycle time (months)	125	144	15.2%

Both JLTV critical technologies are fully mature and, according to officials, have been integrated and tested on production-representative vehicles. The government conducted design understanding reviews for all three competing vehicle designs to assess their technical baselines. The Joint Program Office also conducted production readiness reviews for all three contractors, and, according to officials, ultimately determined all three were qualified for production. In August 2015, the Under Secretary of Defense for Acquisition, Technology, and Logistics approved JLTV for production and deployment. That same month, the Army awarded a production contract to Oshkosh Defense. Contract performance was delayed after one of the losing vendors filed bid protests, which were dismissed in December 2015.

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	....
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	○
• Demonstrate critical processes on a pilot production line	●
• Test a production-representative prototype	●

● Knowledge attained
○ Knowledge not attained
.... Information not available
Not applicable

JLTV Program

Technology and Design Maturity

According to the program office, its two critical technologies–underbelly protection armor and side-kit armor–are fully mature. In May 2014, officials responsible for JLTV requirements oversight recommended that the two different protection levels desired by the Army and Marine Corps be reduced to one requirement and addressed with a single add-on armor configuration. As a result, program officials said the Army and Marine Corps will now both use the same higher protection level configuration. Program officials anticipate this change will result in over $12 million in live fire test and evaluation cost avoidance. According to Army officials, prototype systems with the two armor critical technologies have been tested in a realistic environment, although results were not provided for our review. The Army has declared both technologies mature and demonstrated under operational conditions.

The program office did not hold a formal critical design review during development and instead conducted design understanding reviews with contractors between December 2012 and January 2013. According to program officials, these reviews were at a level of detail similar to a critical design review and verified that all contractors had more than 90 percent of the design files under configuration control.

Production Maturity

According to the Army, the low numbers of vehicles built during system development would not allow for statistically relevant measurements to demonstrate the control of manufacturing processes, such as the use of process capability index data. The production contractor may use this type of data as part of its quality management, but according to the program office there is currently no contractual requirement to do so. To assess production readiness and manufacturing risks prior to production start, the program instead conducted a manufacturing readiness assessment using manufacturing readiness levels. In August and September of 2014, the program held production readiness reviews for the three competing contractors to examine manufacturing process readiness, quality management systems, and production planning. All competing contractors built fully configured production-representative prototypes on pilot production lines. According to Army officials, these production-representative prototypes of all three vehicle variants were subjected to developmental, operational, and live fire testing. Based on those reviews and the pilot production results, the joint program office determined that all three contractors demonstrated proven manufacturing processes and procedures. While the program's manufacturing process maturity may have reached DOD's recommended level for production, it has not reached the level that indicates processes are in control as recommended by GAO best practices.

Other Program Issues

In August 2015, the Under Secretary of Defense for Acquisition, Technology, and Logistics approved JLTV for production and deployment. That same month, the Army awarded a production contract to Oshkosh Defense. Following the award, one of the losing vendors, Lockheed Martin Corporation, filed bid protests with GAO, which were dismissed in December 2015. Performance of the awarded contract was suspended pending resolution of issues raised in bid protests.

Program Office Comments

The program office agreed with the assessment and provided technical comments that were incorporated where appropriate.

Agency Comments and Our Evaluation

We are not making recommendations in this report. DOD provided written comments on a draft of this report. The comments are reprinted in appendix VII. We also received technical comments from DOD, which were incorporated as appropriate.

In its comments, DOD noted that it was pleased that our report identifies ways in which the department continues to drive down the cost of the acquisition portfolio. DOD attributes this decrease in overall cost to the employment of the “Better Buying Power” initiatives. The department also provided a chart tracking the 5-year moving average of annual growth in contract costs over the past 30 years, a measure not used in our analysis, which shows a decline in such growth following the implementation of “Better Buying Power.” We have not included this chart in the appendix as there could be other explanations for this decrease.

We are sending copies of this report to interested congressional committees and offices; the Secretary of Defense; the Secretaries of the Army, Navy, and Air Force; and the Director of the Office of Management and Budget. In addition, the report will be made available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions concerning this report, please contact me at (202) 512-4841. Contact points for our offices of Congressional Relations and Public Affairs may be found on the last page of this report. Staff members making key contributions to this report are listed in appendix VIII.

Michael J. Sullivan
Director, Acquisition and Sourcing Management

List of Committees

The Honorable John McCain
Chairman
The Honorable Jack Reed
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Thad Cochran
Chairman
The Honorable Richard J. Durbin
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Mac Thornberry
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Rodney Frelinghuysen
Chairman
The Honorable Pete Visclosky
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Scope and Methodology

Analysis of the Cost Performance of DOD's Portfolio of Major Defense Acquisition Programs

To develop our 11 observations on the size, cost, and schedule of Department of Defense's (DOD) portfolio of current major defense acquisition programs, we obtained and analyzed cost, quantity, and schedule data from Selected Acquisition Reports (SAR) and other information in the Defense Acquisition Management Information Retrieval Purview system, referred to as DAMIR.[1] We entered this data into a database and verified that the data was entered correctly. We converted all cost information to fiscal year 2016 dollars using conversion factors from the DOD Comptroller's National Defense Budget Estimates for Fiscal Year 2016 (table 5-9). To assess the reliability of the SAR data we talked with a DOD official responsible for DAMIR's data quality control procedures and reviewed relevant documentation. We also confirmed selected data reliability with program offices. We determined that the SAR data and the information retrieved from DAMIR were sufficiently reliable for the purposes of this report. Our assessment includes comparisons of size, cost, and schedule changes over the past year, five years, and from baseline estimates that utilize SAR data from December 2014, December 2013, December 2009, and from the programs' initial SAR submissions. We also analyzed the data to determine the number of programs in each portfolio year. In general, we refer to the 79 major defense acquisition programs with SARs dated December 2014 as DOD's 2015 or current portfolio and use a similar convention for prior year portfolios. We retrieved data on research, development, test, and evaluation; procurement; military construction, acquisition operation and maintenance, total acquisition cost, and schedule estimates for the 79 programs in the 2015 portfolio.[2]

We divided two programs into two distinct elements, because DOD reports performance data on them separately. As a result some of our analysis reflects a total of 81 programs and sub-elements. The Missile Defense Agency's Ballistic Missile Defense System is excluded from all analyses as the program does not have an integrated long-term baseline,

[1]DAMIR Purview is an executive information system operated by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics / Acquisition Resources and Analysis.

[2]We refer to research, development, test, and evaluation costs as research and development or simply as development costs in this report. Total acquisition cost includes research and development and procurement costs as well as acquisition related operation and maintenance and system-specific military construction costs.

which prevents us from assessing the program's cost progress or comparing it to other major defense acquisition programs.

For our first observation, we compared the 2015 portfolio with the programs that issued SARs in December 2013 (2014 portfolio) to identify the programs that exited and entered the current portfolio. We accounted for their cost as well as the difference in cost between the two portfolios.

For the second observation, we aggregated funding stream data for the total planned investment of each portfolio from DAMIR for each year since 2005 to determine any trends. We determined the yearly totals for research and development, procurement, and total acquisition cost. To distinguish the funding already invested from the funding remaining that is needed to complete the programs in each portfolio since 2005, we used funding stream data obtained from DAMIR for each December SAR submission for the years 2004 (2005 portfolio) through 2014 (2015 portfolio). We define funding invested as all funding that has been provided to the programs in the fiscal year of the annual SAR submission (this includes fiscal year 2015 for the December 2014 submission) and earlier, while funding remaining is all the amounts that DOD anticipates will be needed in the fiscal years after the annual SAR submission (fiscal year 2016 and later for the December 2014 submission).

For our third observation, we determined the cost and schedule changes on defense acquisition programs in the current portfolio over the past year, five years, and from baseline estimates. To do this, we collected data from December 2014, December 2013, December 2009, and from programs' initial SARs; acquisition program baselines; and program offices.

For programs less than a year old, we calculated the difference between the December 2014 SAR current estimate and the first full estimate in order to identify the cost and schedule change over the past year. For programs less than five years old, we took a similar approach when calculating the cost and schedule change over the past five years.

For the fourth observation we used SAR data to determine which 10 programs had the largest total acquisition cost, their age, and the total cost and cost growth since first full estimates for two groups of programs—programs started in the past 5 years and program started 5 or more years ago.

For our fifth observation, we divided the programs into percent cost change categories based on the percent change in total acquisition cost they experienced over the past year. We then totaled the number of programs in each category and the total cost change of the programs in each category.

For our sixth observation, in order to determine whether programs experienced an increase or decrease in buying power over the past year and five years, we used data on the programs' number of procurement units, procurement cost changes, and average procurement unit costs.

We first calculated the amount of procurement cost growth attributable to quantity changes. To do this, we multiplied any change in quantity by the average procurement unit cost for the program a year ago.

The resulting dollar amount is considered a change due solely to shifts in the number of units procured and may overestimate the amount of change expected when quantities increase and underestimate the expected change when quantities decrease as it does not account for other effects of quantity changes on procurement such as gain or loss of learning in production that could result in changes to unit cost over time or the use or absence of economic orders of material. However, these changes are accounted for as part of the change in cost not due to quantities. To determine whether any trends in buying power changes occurred over the past five years, once we conducted the calculations just described, we excluded any programs that were not in each of the past five portfolios. As a result, we examined 61 major defense acquisition programs for their buying power increases or decreases over the past five years.

For our seventh observation, we used schedule information from the SARs and calculated the acquisition cycle time from program development start to initial operational capability and any delay in achieving initial operational capability. For programs that do not have a development estimate, we compared the current estimate to the production estimate. For shipbuilding programs with a planning estimate, we compared the current estimate to the planning estimate. For programs that began as pre–major defense acquisition programs, the first full estimate we used as a cost and schedule baseline may differ from the baseline disclosed in the program's initial DOD SAR submission.

For programs in the current portfolio where schedule data for initial operational capability was not available over the past year and five years,

we used a similar methodology as used when calculating cost change for programs that are less than a year old and less than five years old.

For our eighth observation, we determined which programs reported a development cost estimate increase more than 2 percent over the past year and determined how many of these were in production.

For the ninth observation, we evaluated program performance against high-risk criteria discussed by DOD, the Office of Management and Budget (OMB), and GAO. We calculated how many programs had less than a 2 percent increase in total acquisition cost over the past year, less than a 10 percent increase over the past five years, and less than a 15 percent increase from baseline estimates using data from SARs; initial acquisition program baselines; and program offices. We calculated the percentage of programs meeting each of these high-risk criteria for the 2011-2015 portfolios to identify any changes.

For programs with multiple sub-programs presented in the SARs we calculated the net effect of the sub-programs to reach an aggregate program result.

For our 10th observation we used funding stream data from SARs to analyze the percent of total acquisition cost in the 2005-2015 portfolios that is accounted for by each of the services. Where the Department of Defense is identified as the lead component, we allocated the service-specific portion of total acquisition costs: for the F-35 Joint Strike Fighter, to the Air Force and the Navy; and for the Joint Light Tactical Vehicle, to the Army and Navy. The Chemical Demilitarization program, where DOD is identified as the lead, does not have service-specific funding.

For the 11th observation, we used SAR data to determine which 10 programs had the largest total acquisition cost, and the prime contractors associated with these programs. We gathered information from Bloomberg on the equity prices of each of these contractors from 2002 to 2014, and compared the returns from these equities to the S&P 500 and the Industrials sector, as defined by the Standard and Poor's Global Industry Classification Standard.

Analysis of Selected DOD Programs Using Knowledge-Based Criteria

To collect data from current and future major defense acquisition programs—including cost and schedule estimates, technology maturity, and planned implementation of acquisition reforms—we distributed one data collection instrument and two electronic questionnaires, one

questionnaire for the 43 current programs and a slightly different questionnaire for the 12 future programs. Both of the questionnaires were sent by e-mail in an attached Microsoft Word form that respondents could return electronically. We received responses from all of the programs we assessed from August to September 2015. To ensure the reliability of the data collected through the data collection instrument and our questionnaires, we took a number of steps to reduce measurement error and non-response error.

These steps included conducting three pretests of the future major defense acquisition program questionnaire and three pretests for the current major defense acquisition program questionnaire prior to distribution to ensure that our questions were clear, unbiased, and consistently interpreted; reviewing responses to identify obvious errors or inconsistencies; cross-referencing information provided in the data collection instrument with the questionnaire; conducting follow-up to clarify responses when needed; and verifying the accuracy of a sample of keypunched questionnaires. Our pretests covered each branch of the military to better ensure that the questionnaires could be understood by officials within each branch. We determined that the data were sufficiently reliable for the purposes of this report.

Our analysis of how well programs are adhering to a knowledge-based acquisition approach focuses on 43 major defense acquisition programs that are mostly in development or the early stages of production. To assess the knowledge attained by key decision points (system development start or detailed design contract award for shipbuilding programs, critical design review or fabrication start for shipbuilding programs, and production start), we collected data from program offices about their knowledge at each point. In particular, we focused on the seventeen programs that crossed these key acquisition points in 2015 or planned to in early 2016 and evaluated their adherence to knowledge based practices.

We also provide information on how much knowledge is obtained at key decision points by programs that accomplished these previously. We also included observations on the knowledge that 12 future programs expect to obtain before starting development. We did not validate the data provided by the program offices, but reviewed the data and performed various checks to determine that they were reliable enough for our purposes. Where we discovered discrepancies, we clarified the data accordingly.

The 55 current and future programs included in our assessment were in various stages of the acquisition cycle, and not all of the programs provided information on knowledge obtained at each point. Programs were not included in our assessments at key decision points if relevant data were not available. Our analysis of knowledge attained at each key point includes factors that we have previously identified as being key to a knowledge-based acquisition approach, including holding early systems engineering reviews, testing an integrated prototype prior to the design review, using a reliability growth curve, planning for manufacturing, and testing a production-representative prototype prior to the making a production decision. Additional information on how we collect these data is found in the product knowledge assessment section of appendix I. See also appendix IV for a list of the practices that are associated with a knowledge-based acquisition approach.

Analysis of Acquisition Initiatives and Program Concurrency

To develop observations on how DOD is implementing acquisition reforms, we reviewed the DOD Instruction 5000.02, the Weapon Systems Acquisition Reform Act of 2009 (WSARA), and the September 19, 2014, Under Secretary of Defense for Acquisition, Technology, and Logistics "Better Buying Power 3.0 Interim Release." and previous releases of DOD's "Better Buying Power" memoranda.[3] We analyzed questionnaire data received from the 43 current and 12 future major defense acquisition programs in our assessment to determine the extent to which acquisition reforms have been implemented. We determined which programs have established affordability constraints and, for current programs, examined the median development cost growth on programs with these constraints compared to those without. We tallied programs that conducted "should-cost" analyses and identified realized and/or future potential savings. We also analyzed whether programs are planning for competition throughout the acquisition life-cycle.

To examine programs' software development efforts we identified the programs that reported their software as high-risk. We used the questionnaire responses from these programs to assess the reasons why they identified their software effort as high-risk and the metrics programs reported using to manage their software development. We identified the dates reported by programs for their software and hardware integration

[3]Pub. L. No. 111-23.

and compared those dates to each program's production start date to assess each programs' degree of software development and production concurrency. We also determined the average difference in schedule delay for programs that identified their software development as high risk versus those that did not.

To assess program development testing and production concurrency we identified the programs—among those we included in our assessment—with production start dates. We used the questionnaire responses from those programs to identify the dates for the start and end of developmental testing, compared those dates to the timing of each program's production decision and determined the number of months, if any, of developmental testing done after production start. We then compared the number of overlapping months to the total number of months of developmental testing for each program and calculated the percentage of developmental testing done concurrent with production. Lastly, we analyzed the correlation between concurrency and total acquisition cost growth for programs in production, and the correlation between total acquisition cost and concurrency.

Individual Assessments of Weapon Programs

In total, this report presents individual assessments of 55 weapon programs. A table listing these programs is found in appendix VIII. Out of these programs, 42 are captured in a two-page format discussing technology, design, and manufacturing knowledge obtained and other program issues. Thirty-nine of these 42 two-page assessments are of major defense acquisition programs, most of which are in development or early production and three assessments are of programs that were projected to become major defense acquisition programs during or soon after our review. The remaining 13 programs are described in a one-page format that describes their current status. Those one-page assessments include 12 future major defense acquisition programs and one major defense acquisition program that is well into production.

For presentation purposes we grouped the individual assessments by lead service—Army, Navy and Marine Corps, Air Force, and DOD-led—and inserted a lead service separator page at the start of each grouping. These four separator pages summarize information about the acquisition phase, current estimated funding needs, cost and schedule growth, and product knowledge attained that is provided in the one and two-page assessments. We report cost and schedule growth in the separator pages in a manner that is consistent with how it is reported and described elsewhere in the report. Estimates of funding needed to complete in the separator pages are based on all amounts that will be provided in fiscal

year 2016 and later. For some future major defense acquisition programs the estimates of funding needed represents only those amounts provided through fiscal year 2020 and are not a full to complete amount.

Over the past several years, DOD has revised policies governing weapon system acquisitions and changed the terminology used for major acquisition events. To make DOD's acquisition terminology more consistent across the 55 program assessments, we standardized the terminology for key program events. For most individual programs in our assessment, "development start" refers to the initiation of an acquisition program as well as the start of engineering and manufacturing development or system development. This generally coincides with DOD's milestone B. A few programs in our assessment have a separate "program start" date, which begins a pre–system development phase for program definition and risk-reduction activities. This "program start" date generally coincides with DOD's former terminology for milestone I or DOD's current milestone A, which denotes the start of technology maturation and risk reduction. The "production decision" generally refers to the decision to enter the production and deployment phase, typically with low-rate initial production. The "initial capability" refers to the initial operational capability—sometimes called first unit equipped or required asset availability. For shipbuilding programs, the schedule of key program events in relation to acquisition milestones varies for each program. Our work on shipbuilding best practices has identified the detailed design contract award and the start of lead ship fabrication as the points in the acquisition process roughly equivalent to development start and design review for other programs.

For each program we assessed in a two-page format, we present cost, schedule, and quantity data at the program's first full estimate and an estimate from the latest SAR or the program office reflecting 2015 data where they were available. The first full estimate is generally the cost estimate established at milestone B—development start; however, for a few programs that did not have such an estimate, we used the estimate at milestone C—production start—instead. For shipbuilding programs, we used their planning estimates if those estimates were available. For systems for which a first full estimate was not available, we only present the latest available estimate of cost and quantities. For the other programs assessed in a one-page format, we present the latest available estimate of cost and quantity from the program office.

For each program we assessed, all cost information is presented in fiscal year 2016 dollars. We converted cost information to fiscal year 2016

dollars using conversion factors from the DOD Comptroller's National Defense Budget Estimates for Fiscal Year 2016 (table 5-9). We have depicted only the program's main elements of acquisition cost—research and development and procurement. However, the total program cost also includes military construction and acquisition-related operation and maintenance costs. Because of rounding and these additional costs, in some situations, total cost may not match the exact sum of the research and development and procurement costs. The program unit costs are calculated by dividing the total program cost by the total quantities planned. In some instances, the data were not applicable, and we annotate this by using the term "not applicable (NA)." The quantities listed refer to total quantities, including both procurement and development quantities.

The schedule assessment for each program is based on acquisition cycle time, defined as the number of months between program start and the achievement of initial operational capability or an equivalent fielding date. In some instances the data were not yet available, and we annotate this by using the term "to be determined (TBD)" or "NA."

The information presented on the "funding needed to complete" is from fiscal year 2016 through completion and, unless otherwise noted, draws on information from SARs or on data from the program office. In some instances, the data were not available, and we annotate this by the term "TBD" or "NA." The quantities listed refer only to procurement quantities. Satellite programs, in particular, produce a large percentage of their total operational units as development quantities, which are not included in the quantity figure.

The intent of these comparisons is to provide an aggregate, or overall, picture of a program's history. These assessments represent the sum of the federal government's actions on a program, not just those of the program manager and the contractor. DOD does a number of detailed analyses of changes that attempt to link specific changes with triggering events or causes. Our analysis does not attempt to make such detailed distinctions.

In this year's assessment we also reviewed whether individual subcontracting reports from a program's prime contractor or contractors were accepted on the Electronic Subcontracting Reporting System (eSRS). We reviewed this information for 79 of the major defense acquisition programs included in our assessment using the contract

information reported in their December 2014 Selected Acquisition Reports. See appendix VI for a list of the programs we reviewed.

Product Knowledge Data on Individual Two-Page Assessments

In our past work examining weapon acquisition issues and best practices for product development, we have found that leading commercial firms pursue an acquisition approach that is anchored in knowledge, whereby high levels of product knowledge are demonstrated by critical points in the acquisition process. On the basis of this work, we have identified three key knowledge points during the acquisition cycle—system development start, critical design review, and production start—at which programs need to demonstrate critical levels of knowledge to proceed. To assess the product development knowledge of each program at these key points, we reviewed data-collection instruments and questionnaires submitted by programs; however, not every program had responses to each element of the data-collection instrument or questionnaire. We also reviewed pertinent program documentation and discussed the information presented on the data-collection instrument and questionnaire with program officials as necessary.

To assess a program's readiness to enter system development, we collected data through the data-collection instrument on critical technologies and early design reviews. To assess technology maturity, we asked program officials to apply a tool, referred to as technology readiness levels (TRL), for our analysis. The National Aeronautics and Space Administration originally developed TRLs, and the Army and Air Force science and technology research organizations use them to determine when technologies are ready to be handed off from science and technology managers to product developers. TRLs are measured on a scale from 1 to 9, beginning with paper studies of a technology's feasibility and culminating with a technology fully integrated into a completed product. See appendix V for TRL definitions. Our best-practices work has shown that a TRL 7—demonstration of a technology in an operational environment—is the level of technology maturity that constitutes a low risk for starting a product development program.[4] For shipbuilding programs, we have recommended that this level of maturity

[4]GAO, *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999); GAO, *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001).

be achieved by the contract award for detailed design.[5] In our assessment, the technologies that have reached TRL 7, a prototype demonstrated in an operational environment, are referred to as mature or fully mature. Those technologies that have reached TRL 6, a prototype demonstrated in a relevant environment, are referred to as approaching or nearing maturity. Satellite technologies that have achieved TRL 6 are assessed as fully mature due to the difficulty of demonstrating maturity in an operational environment—space. In addition, we asked program officials to provide the date of the preliminary design review. We compared this date to the system development start date.

In most cases, we did not validate the program offices' selection of critical technologies or the determination of the demonstrated level of maturity. We sought to clarify the TRLs in those cases where information existed that raised concerns. If we were to conduct a detailed review, we might adjust the critical technologies assessed, their readiness levels demonstrated, or both. It was not always possible to reconstruct the technological maturity of a weapon system at key decision points after the passage of many years. Where practicable, we compared technology assessments provided by the program office to assessments conducted by officials from the Office of the Assistant Secretary of Defense for Research and Engineering.

To assess design stability, we asked program officials to provide the percentage of design drawings completed or projected for completion by the design review, the production decision, and as of our current assessment in the data-collection instrument. In most cases, we did not verify or validate the percentage of engineering drawings provided by the program office. We clarified the percentage of drawings completed in those cases where information that raised concerns existed. Completed drawings were defined as the number of drawings released or deemed releasable to manufacturing that can be considered the "build to" drawings. For shipbuilding programs, we asked program officials to provide the percentage of the three-dimensional product model that had been completed by the start of lead ship fabrication, and as of our current assessment. To gain greater insights into design stability, we also asked program officials to provide the date they planned to first integrate and

[5]GAO, *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*, GAO-09-322 (Washington, D.C.: May 13, 2009).

test all key subsystems and components into a system-level integrated prototype. We compared this date to the date of the design review. We did not assess whether shipbuilding programs had completed integrated prototypes.

To assess production maturity, we asked program officials to identify the number of critical manufacturing processes and, where available, to quantify the extent of statistical control achieved for those processes as a part of our data-collection instrument. In most cases, we did not verify or validate the information provided by the program office. We clarified the number of critical manufacturing processes and the percentage of statistical process control where information existed that raised concerns. We used a standard called the Process Capability Index, a process-performance measurement that quantifies how closely a process is running to its specification limits. The index can be translated into an expected product defect rate, and we have found it to be a best practice. We also used data provided by the program offices on their manufacturing readiness levels (MRL) for process capability and control, a sub-thread tracked as part of the manufacturing readiness assessment process recommended by DOD, to determine production maturity. We assessed programs as having mature manufacturing processes if they reported an MRL 9 for that sub-thread—meaning, that manufacturing processes are stable, adequately controlled, and capable. To gain further insights into production maturity, we asked program officials whether the program planned to demonstrate critical manufacturing processes on a pilot production line before beginning low-rate production. We also asked programs on what date they planned to begin system-level developmental testing of a fully configured, production- representative prototype in its intended environment. We compared this date to the production start date. We did not assess production maturity for shipbuilding programs.

Although the knowledge points provide excellent indicators of potential risks, by themselves they do not cover all elements of risk that a program encounters during development, such as funding instability. Our detailed reviews on individual systems normally provide a more comprehensive assessment of risk elements.

We conducted this performance audit from June 2015 to March 2016, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Current and First Full Estimates for DOD's 2015 Portfolio of Major Defense Acquisition Programs

Table 7 contains the current and first full total acquisition cost estimates (in fiscal year 2016 dollars) for each program or element in the Department of Defense's (DOD) 2015 major defense acquisition program portfolio. For each program we show the percent change in total acquisition cost from the first full estimate, as well as over the past year and 5 years.

Table 7: Current Cost Estimates and First Full Estimates for DOD's 2015 Portfolio of Major Defense Acquisition Programs

Program name	Current total acquisition cost	First full estimate total acquisition cost	Change in total acquisition cost from first full estimate (percent)	Change in total acquisition cost within the past year (percent)	Change in total acquisition cost within the past 5 years (percent)
Advanced Extremely High Frequency (AEHF) Satellite	$14,795	$6,835	116.5%	0.9%	5.2%
AGM-88E Advanced Anti-Radiation Guided Missile (AGM-88E AARGM)	$2,274	$1,718	32.4%	-0.2%	14.5%
AH-64E Apache New Build (AH-64E New Build)	$2,319	$2,542	-8.8%	0.4%	-8.8%
AH-64E Apache Remanufacture (AH-64E Remanufacture)	$13,992	$7,771	80.1%	-0.6%	21.5%
AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM)	$25,069	$11,727	113.8%	0.8%	-3.7%
AIM-9X Block II Air-to-Air Missile (AIM-9X Block II)	$3,506	$4,287	-18.2%	-4.5%	-18.2%
Air and Missile Defense Radar (AMDR)	$5,232	$5,998	-12.8%	-0.5%	-12.8%
Airborne and Maritime/Fixed Station Joint Tactical Radio System (AMF JTRS)	$3,590	$8,748	-59.0%	2.0%	-59.9%
Airborne Warning and Control System Block 40/45 Upgrade (AWACS Blk 40/45 Upgrade)	$2,837	$2,996	-5.3%	-0.1%	-5.3%
B-2 Extremely High Frequency SATCOM and Computer Increment 1 (B-2 EHF Inc1)	$589	$762	-22.7%	0.5%	-12.6%
B61 Mod 12 Life Extension Program Tailkit Assembly (B61 Mod 12 LEP TKA)	$1,377	$1,403	-1.8%	-1.5%	-1.8%
C-130J Hercules Transport Aircraft (C-130J)	$17,056	$1,018	1575.1%	0.5%	2.2%
C-5 Reliability Enhancement and Re-engineering Program (C-5 RERP)	$7,563	$11,701	-35.4%	-0.4%	-5.5%
CH-47F Improved Cargo Helicopter (CH-47F)	$16,032	$3,454	364.1%	0.2%	8.8%
CH-53K Heavy Lift Replacement Helicopter (CH-53K)	$25,708	$17,765	44.7%	0.2%	7.8%
Chemical Demilitarization-Assembled Chemical Weapons Alternatives (Chem Demil-ACWA)	$11,071	$2,835	290.5%	0.4%	28.0%
Combat Rescue Helicopter (CRH)	$8,426	$8,335	1.1%	1.1%	1.1%
Cooperative Engagement Capability (CEC)	$5,777	$3,158	82.9%	2.2%	4.8%
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	$23,066	$37,341	-38.2%	1.2%	6.9%

Program name	Current total acquisition cost	First full estimate total acquisition cost	Change in total acquisition cost from first full estimate (percent)	Change in total acquisition cost within the past year (percent)	Change in total acquisition cost within the past 5 years (percent)
DDG 51 Arleigh Burke Class Guided Missile Destroyer (DDG 51)	$115,169	$16,297	606.7%	2.9%	12.1%
E-2D Advanced Hawkeye Aircraft (E-2D AHE)	$21,538	$15,827	36.1%	1.1%	10.9%
EA-18G Growler Aircraft (EA-18G)	$15,305	$9,630	58.9%	11.1%	21.2%
Enhanced Polar System (EPS)	$1,425	$1,431	-0.4%	-0.4%	-0.4%
Evolved Expendable Launch Vehicle (EELV)	$60,497	$18,642	224.5%	-2.7%	224.5%
Excalibur Precision 155mm Projectiles (Excalibur)	$1,962	$5,125	-61.7%	0.3%	-26.1%
F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)	$1,565	$1,608	-2.6%	-1.3%	-2.6%
F-35 Joint Strike Fighter (F-35)	$339,997	$229,285	48.3%	-1.0%	10.1%
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)	$4,308	$3,421	25.9%	-10.6%	0.7%
Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)	$36,438	$38,172	-4.5%	-0.9%	-2.1%
Global Broadcast Service (GBS)	$1,291	$618	109.0%	2.3%	6.0%
Global Positioning System III (GPS III)	$4,918	$4,229	16.3%	4.5%	9.0%
Ground/Air Task Oriented Radar (G/ATOR)	$2,775	$1,573	76.5%	0.0%	76.5%
Guided Multiple Launch Rocket System/Guided Multiple Launch Rocket Sys Alt Warhead (GMLRS/GMLRS AW)	$6,863	$1,897	261.8%	-2.1%	9.3%
H-1 Upgrades (4BW/4BN) (H-1 Upgrades)	$13,211	$3,891	239.5%	-2.3%	2.2%
HC/MC-130 Recapitalization Aircraft (HC/MC-130 Recap)	$14,424	$8,974	60.7%	-0.7%	60.7%
Integrated Air and Missile Defense (IAMD)	$6,371	$5,395	18.1%	0.8%	18.1%
Integrated Defensive Electronic Countermeasures (IDECM)	$2,680	$2,336	14.7%	0.5%	10.7%
IDECM Block 4	$923	$745	24.0%	1.5%	22.5%
IDECM Blocks 2/3	$1,757	$1,591	10.4%	-0.1%	5.3%
Intercontinental Ballistic Missile Fuze Modernization (ICBM Fuze Mod)	$1,882	$1,870	0.7%	0.7%	0.7%
Joint Air-to-Surface Standoff Missile (JASSM)	$7,346	$2,487	195.4%	0.7%	-6.4%
Joint Direct Attack Munition (JDAM)	$9,205	$3,668	151.0%	10.4%	32.5%
Joint Light Tactical Vehicle (JLTV)	$23,956	$24,178	-0.9%	-0.3%	-0.9%
Joint Precision Approach and Landing System Increment 1A (JPALS Inc 1A)	$1,590	$1,086	46.4%	-1.8%	50.3%
Joint Standoff Weapon - Baseline Variant and Unitary Warhead Variant (JSOW)	$4,389	$8,527	-48.5%	-26.2%	-24.4%
JSOW - Baseline Varient	$2,215	$3,065	-27.7%	-7.4%	-7.8%
JSOW - Unitary Warhead Varient	$2,174	$5,462	-60.2%	-38.9%	-36.1%
Joint Tactical Networks (JTN)	$2,316	$1,052	120.1%	-0.3%	6.6%

Program name	Current total acquisition cost	First full estimate total acquisition cost	Change in total acquisition cost from first full estimate (percent)	Change in total acquisition cost within the past year (percent)	Change in total acquisition cost within the past 5 years (percent)
Handheld, Manpack, and Small Form Fit Radios (HMS)	$9,130	$10,769	-15.2%	-13.0%	75.2%
KC-130J Transport Aircraft (KC-130J)	$9,739	$10,176	-4.3%	-5.9%	-4.3%
KC-46 Tanker Modernization Program (KC-46A)	$43,532	$47,021	-7.4%	-0.4%	-7.4%
LHA 6 America Class Amphibious Assault Ship (LHA 6)	$9,971	$3,412	192.2%	-2.5%	43.3%
Littoral Combat Ship - Mission Packages (LCS MP)	$6,930	$7,031	-1.4%	2.0%	-1.4%
Littoral Combat Ship (LCS)	$20,954	$2,408	NA	-3.0%	NA
LPD 17 San Antonio Class Amphibious Transport Dock (LPD 17)	$21,283	$12,567	69.4%	6.2%	6.4%
M109A7 Family of Vehicles	$7,201	$7,176	0.4%	0.3%	0.4%
MH-60R Multi-Mission Helicopter (MH-60R)	$14,574	$5,940	145.4%	5.3%	-6.7%
Mobile User Objective System (MUOS)	$7,719	$7,211	7.0%	0.2%	3.8%
MQ-1C Gray Eagle Unmanned Aircraft System (MQ-1C Gray Eagle)	$5,253	$1,089	382.2%	7.5%	-3.2%
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)	$12,815	$13,783	-7.0%	-7.2%	-9.7%
MQ-8 (Fire Scout)	$2,918	$2,806	4.0%	-5.9%	8.5%
MQ-9 Reaper Unmanned Aircraft System (MQ-9 Reaper)	$12,154	$2,829	329.6%	3.8%	0.3%
Multifunctional Information Distribution System (MIDS)	$4,098	$1,399	192.9%	2.7%	28.0%
Navy Multiband Terminal (NMT)	$2,132	$2,490	-14.4%	6.9%	-2.3%
Next Generation Operational Control System (GPS OCX)	$3,737	$3,553	5.2%	5.4%	5.2%
P-8A Poseidon Multi-Mission Maritime Aircraft (P-8A)	$33,269	$33,297	-0.1%	-0.5%	-5.6%
Patriot Advanced Capability-3 Missile Enhancement (PAC-3 MSE)	$6,354	$7,818	-18.7%	-23.5%	-24.0%
Remote Minehunting System (RMS)	$1,574	$1,547	1.8%	2.3%	13.4%
RQ-4A/B Global Hawk Unmanned Aircraft System (RQ-4A/B Global Hawk)	$10,039	$5,786	73.5%	-1.3%	-32.1%
Ship to Shore Connector Amphibious Craft (SSC)	$4,087	$4,242	-3.7%	-0.5%	-3.7%
Small Diameter Bomb Increment II (SDB II)	$3,970	$5,045	-21.3%	0.5%	-21.3%
Space Based Infrared System High (SBIRS High)	$19,135	$4,932	288.0%	1.1%	10.1%
Space Fence Ground-Based Radar System Increment 1	$1,588	$1,614	-1.6%	-1.6%	-1.6%
SSN 774 Virginia Class Submarine (SSN 774)	$91,144	$64,857	40.5%	5.5%	1.8%
Standard Missile-6 (SM-6)	$8,963	$6,116	46.6%	-3.9%	34.2%
Tactical Tomahawk RGM-109E/UGM 109E Missile (TACTOM)	$6,255	$2,270	175.5%	5.5%	-16.1%
Trident II (D-5) Sea-Launched Ballistic Missile UGM 133A (Trident II Missile)	$57,803	$55,504	4.1%	0.1%	3.2%

Program name	Current total acquisition cost	First full estimate total acquisition cost	Change in total acquisition cost from first full estimate (percent)	Change in total acquisition cost within the past year (percent)	Change in total acquisition cost within the past 5 years (percent)
UH-60M Black Hawk Helicopter (UH-60M Black Hawk)	$26,273	$13,917	88.8%	2.4%	10.0%
V-22 Osprey Joint Services Advanced Vertical Lift Aircraft (V-22)	$61,891	$43,023	43.9%	0.2%	1.4%
VH-92A Presidential Helicopter Replacement Program	$4,817	$4,790	0.6%	0.6%	0.6%
Warfighter Information Network-Tactical Increment 2 (WIN-T Inc 2)	$10,433	$3,979	162.2%	-17.8%	102.0%
Warfighter Information Network-Tactical Increment 3 (WIN-T Inc 3)	$2,025	$17,560	-88.5%	-45.2%	-86.3%
Wideband Global SATCOM (WGS)	$4,109	$1,281	220.8%	-1.1%	6.0%

Source: GAO analysis of DOD data. | GAO-16-329SP

Notes: Data were obtained from DOD's Selected Acquisition Reports, acquisition program baselines, and, in some cases, program offices.

Appendix III: Changes in DOD's 2015 Portfolio of Major Defense Acquisition Programs over Five Years and Since First Full Estimates

Table 8 shows the change in research and development cost, procurement cost, total acquisition cost, and average delay in delivering initial operational capability for those programs in Department of Defense's (DOD) 2015 portfolio over the last 5 years and since their first full cost and schedule estimates.

Table 8: Cost and Schedule Changes for Programs in DOD's 2015 Portfolio

Fiscal year 2016 dollars (in billions)

	5-year comparison (2010-2015)	Since first full estimate (Baseline to 2015)
Change in total research and development cost	$22.1	$102.2
	8.3%	54.7%
Change in total procurement cost	$70.8	$364.9
	6.6%	47.2%
Change in total other acquisition costs	$2.8	$1.6
	27.9%	14.2%
Change in total acquisition cost[a]	$95.7	$468.7
	7.1%	48.3%
Average delay in delivering initial capabilities	10.8 months	29.5 months
	11.1%	36.6%

Source: GAO analysis of DOD data. | GAO-16-329SP

Notes: Data were obtained from DOD's Selected Acquisition Reports and acquisition program baselines. In a few cases data were obtained directly from program offices. Some numbers may not sum due to rounding.

[a]In addition to research and development and procurement costs, total acquisition cost includes acquisition-related operation and maintenance and system-specific military construction costs.

Appendix IV: Knowledge-Based Acquisition Practices

GAO's prior work on best product-development practices found that successful programs take steps to gather knowledge that confirms that their technologies are mature, their designs stable, and their production processes are in control. Successful product developers ensure a high level of knowledge is achieved at key junctures in development. We characterize these junctures as knowledge points. The Related GAO Products section of this report includes references to the body of work that helped us identify these practices and apply them as criteria in weapon system reviews. Table 9 summarizes these knowledge points and associated key practices.

Table 9: Best Practices for Knowledge-Based Acquisitions

Knowledge Point 1: Technologies, time, funding, and other resources match customer needs. Decision to invest in product development
Demonstrate technologies to a high readiness level—Technology Readiness Level 7—to ensure technologies will work in an operational environment[a]
Ensure that requirements for product increment are informed by preliminary design review using systems engineering process (such as prototyping of preliminary design)
Establish cost and schedule estimates for product on the basis of knowledge from preliminary design using systems engineering tools (such as prototyping of preliminary design)
Constrain development phase (5 to 6 years or less) for incremental development
Ensure development phase fully funded (programmed in anticipation of milestone)
Align program manager tenure to complete development phase
Contract strategy that separates system integration and system demonstration activities
Conduct independent cost estimate
Conduct independent program assessment
Conduct major milestone decision review for development start
Knowledge Point 2: Design is stable and performs as expected. Decision to start building and testing production-representative prototypes
Complete system critical design review
Complete 90 percent of engineering design drawing packages
Complete subsystem and system design reviews
Demonstrate with system-level integrated prototype that design meets requirements
Complete the failure modes and effects analysis
Identify key system characteristics
Identify critical manufacturing processes
Establish reliability targets and growth plan on the basis of demonstrated reliability rates of components and subsystems
Conduct independent cost estimate
Conduct independent program assessment
Conduct major milestone decision review to enter system demonstration

Knowledge Point 3: Production meets cost, schedule, and quality targets. Decision to produce first units for customer
Demonstrate manufacturing processes
Build and test production-representative prototypes to demonstrate product in intended environment
Test production-representative prototypes to achieve reliability goal
Collect statistical process control data
Demonstrate that critical processes are capable and in statistical control
Conduct independent cost estimate
Conduct independent program assessment
Conduct major milestone decision review to begin production

Source: GAO. GAO-16-329P

[a]DOD considers Technology Readiness Level 6, demonstrations in a relevant environment, to be appropriate for programs entering system development; therefore, we have analyzed programs against this measure as well.

Appendix V: Technology Readiness Levels

	Technology readiness level	Description	Hardware/software	Demonstration environment
1.	Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties	None (paper studies and analysis)	None
2.	Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.	None (paper studies and analysis)	None
3.	Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.	Analytical studies and demonstration of non-scale individual components (pieces of subsystem)	Lab
4.	Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in a laboratory.	Low-fidelity breadboard. Integration of non-scale components to show pieces will work together. Not fully functional or form or fit but representative of technically feasible approach suitable for flight articles.	Lab
5.	Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components.	High-fidelity breadboard. Functionally equivalent but not necessarily form and/or fit (size weight, materials, etc.). Should be approaching appropriate scale. May include integration of several components with reasonably realistic support elements/subsystems to demonstrate functionality.	Lab demonstrating functionality but not form and fit. May include flight demonstrating breadboard in surrogate aircraft. Technology ready for detailed design studies.
6.	System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated realistic environment.	Prototype. Should be very close to form, fit and function. Probably includes the integration of many new components and realistic supporting elements/subsystems if needed to demonstrate full functionality of the subsystem.	High-fidelity lab demonstration or limited/restricted flight demonstration for a relevant environment. Integration of technology is well defined.
7.	System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in a realistic environment, such as in an aircraft, vehicle or	Prototype. Should be form, fit and function integrated with other key supporting elements/subsystems to demonstrate full functionality of	Flight demonstration in representative realistic environment such as flying test bed or demonstrator aircraft.

	Technology readiness level	Description	Hardware/software	Demonstration environment
		space. Examples include testing the prototype in a test bed aircraft.	subsystem.	Technology is well substantiated with test data.
8.	Actual system completed and "flight qualified" through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.	Flight-qualified hardware	Developmental Test and Evaluation in the actual system application.
9.	Actual system "flight proven" through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.	Actual system in final form	Operational Test and Evaluation in operational mission conditions.

Source: GAO and its analysis of National Aeronautics and Space Administration data. GAO-16-329SP

Appendix VI: Major Defense Acquisition Programs’ Individual Subcontracting Reports in the Electronic Subcontracting Reporting System

Table 10 shows the number of prime contractors for the programs we assessed where an individual subcontracting report is reported as accepted during 2015 in the Electronic Subcontracting Reporting System (eSRS). We reviewed this information for 79 major defense acquisition programs included in our assessment that reported prime contract information in their December 2014 Selected Acquisition Report (SAR) submissions. The government uses individual subcontracting reports from eSRS as one method of monitoring small business participation, as this tool includes information on contractors’ performance against small business subcontracting goals. There are multiple reasons why a prime contractor may not have an accepted subcontracting report in eSRS. For example, some contractors may have pending or rejected reports within the system as all reports are reviewed prior to acceptance. Not all prime contracts for major defense acquisition programs are required to submit individual subcontracting reports. Instead, some contractors report small business participation at a corporate level as opposed to the program level and this data is not captured in the individual subcontracting reports.[1] In addition, although a prime contractor may be required to submit a report, it may not yet have done so for the period we reviewed.[2]

[1]As of November 2015, 12 major defense companies were participating in the Test Program for Negotiation of Comprehensive Small Business Subcontracting Plans created by the National Defense Authorization Act for Fiscal Years 1990 and 1991, Pub. L. No. 101-189, § 834 (1989). One additional company ceased participation in 2007, although active contracts awarded before that time are still reported through the test program. These major defense companies have each established a comprehensive subcontracting plan on a corporate, division or plant-wide basis under which a single summary subcontract report is submitted semi-annually for any covered DOD contracts. The test program has been extended by Congress several times with the current three year extension made by Pub. L. No. 113-291, § 821 (2014) to end on December 31, 2017. Participation in the test program is on a voluntary basis such that these major defense companies may have contracts where they are reporting on an individual basis as well as contracts where they are reporting on a comprehensive basis.

[2]For further information on the limitations of eSRS and other contract reporting systems, see GAO, *Federal Subcontracting: Linking Small Business Subcontractors to Prime Contracts Is Not Feasible Using Current Systems*, GAO-15-116 (Washington, D.C.: Dec. 11, 2014).

Table 10: Major Defense Acquisition Programs' Individual Subcontracting Reports in the Electronic Subcontracting Reporting System

Program name	Number of contracts listed in the December 2014 SAR	Contracts with an accepted individual subcontracting report (as of December 2015)
Advanced Extremely High Frequency (AEHF) Satellite	2	0
AGM-88E Advanced Anti-Radiation Guided Missile (AGM-88E AARGM)	2	2
AH-64E Apache New Build (AH-64E New Build)	1	1
AH-64E Apache Remanufacture (AH-64E Remanufacture)	5	2
AIM-9X Block II Air-to-Air Missile (AIM-9X Block II)	4	0
Air and Missile Defense Radar (AMDR)	1	0
Airborne and Maritime/Fixed Station Joint Tactical Radio System (AMF JTRS)	0	0
AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM)	6	0
Airborne Warning and Control System Block 40/45 Upgrade (AWACS Blk 40/45 Upgrade)	1	0
B-2 Extremely High Frequency SATCOM and Computer Increment 1 (B-2 EHF Inc1)	1	1
B61 Mod 12 Life Extension Program Tailkit Assembly (B61 Mod 12 LEP TKA)	1	1
C-130J Hercules Transport Aircraft (C-130J)	4	0
C-5 Reliability Enhancement and Re-engineering Program (C-5 RERP)	1	0
Cooperative Engagement Capability (CEC)	4	0
CH-47F Improved Cargo Helicopter (CH-47F)	1	1
CH-53K Heavy Lift Replacement Helicopter (CH-53K)	2	0
Chemical Demilitarization-Assembled Chemical Weapons Alternatives (Chem Demil-ACWA)	2	2
Combat Rescue Helicopter (CRH)	1	0
Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)	4	3
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	3	3
DDG 51 Arleigh Burke Class Guided Missile Destroyer (DDG 51)	6	5
E-2D Advanced Hawkeye Aircraft (E-2D AHE)	5	2
EA-18G Growler Aircraft (EA-18G)	6	4
Evolved Expendable Launch Vehicle (EELV)	4	3
Enhanced Polar System (EPS)	1	1
Excalibur Precision 155mm Projectiles (Excalibur)	2	0
F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)	1	0
F-35 Joint Strike Fighter (F-35)	6	0

Program name	Number of contracts listed in the December 2014 SAR	Contracts with an accepted individual subcontracting report (as of December 2015)
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)	2	0
MQ-8 (Fire Scout)	1	1
Ground/Air Task Oriented Radar (G/ATOR)	1	0
Global Broadcast Service (GBS)	1	0
Guided Multiple Launch Rocket System/Guided Multiple Launch Rocket Sys Alt Warhead (GMLRS/GMLRS AW)	4	0
Global Positioning System III (GPS III)	2	1
Next Generation Operational Control System (GPS OCX)	1	0
H-1 Upgrades (4BW/4BN) (H-1 Upgrades)	5	3
HC/MC-130 Recapitalization Aircraft (HC/MC-130 Recap)	3	0
Integrated Air and Missile Defense (IAMD)	2	1
Intercontinental Ballistic Missile Fuze Modernization (ICBM Fuze Mod)	1	0
Integrated Defensive Electronic Countermeasures (IDECM) Block 4	3	1
Joint Air-to-Surface Standoff Missile (JASSM)	3	0
Joint Direct Attack Munition (JDAM)	2	2
Joint Light Tactical Vehicle (JLTV)	3	2
Joint Precision Approach and Landing System Increment 1A (JPALS Inc 1A)	1	0
Joint Standoff Weapon - Baseline and Unitary Warhead Varient (JSOW)	0	0
Joint Tactical Networks (JTN)	0	0
Joint Tactical Radio System Handheld, Manpack, and Small Form Fit Radios (JTRS HMS)	1	0
KC-130J Transport Aircraft (KC-130J)	4	0
KC-46 Tanker Modernization Program (KC-46A)	3	3
Littoral Combat Ship (LCS)	2	1
Littoral Combat Ship - Mission Packages (LCS MP)	1	0
LHA 6 America Class Amphibious Assault Ship (LHA 6)	1	1
LPD 17 San Antonio Class Amphibious Transport Dock (LPD 17)	1	1
M109A7 Family of Vehicles	2	2
MH-60R Multi-Mission Helicopter (MH-60R)	4	0
Multifunctional Information Distribution System (MIDS)	2	2
MQ-1C Gray Eagle Unmanned Aircraft System (MQ-1C Gray Eagle)	5	4
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)	1	1
MQ-9 Reaper Unmanned Aircraft System (MQ-9 Reaper)	3	0
Mobile User Objective System (MUOS)	1	0

Program name	Number of contracts listed in the December 2014 SAR	Contracts with an accepted individual subcontracting report (as of December 2015)
Navy Multiband Terminal (NMT)	1	0
P-8A Poseidon Multi-Mission Maritime Aircraft (P-8A)	3	2
Patriot Advanced Capability-3 Missile Enhancement (PAC-3 MSE)	3	0
Remote Minehunting System (RMS)	2	0
RQ-4A/B Global Hawk Unmanned Aircraft System (RQ-4A/B Global Hawk)	0	0
Space Based Infrared System High (SBIRS High)	4	0
Small Diameter Bomb Increment II (SDB II)	1	0
Standard Missile-6 (SM-6)	3	0
Space Fence Ground-Based Radar System Increment 1	1	0
Ship to Shore Connector Amphibious Craft (SSC)	1	1
SSN 774 Virginia Class Submarine (SSN 774)	2	2
Tactical Tomahawk RGM-109E/UGM 109E Missile (TACTOM)	2	0
Trident II (D-5) Sea-Launched Ballistic Missile UGM 133A (Trident II Missile)	8	2
UH-60M Black Hawk Helicopter (UH-60M Black Hawk)	1	0
V-22 Osprey Joint Services Advanced Vertical Lift Aircraft (V-22)	5	4
VH-92A Presidential Helicopter Replacement Program	1	0
Wideband Global SATCOM (WGS)	1	1
Warfighter Information Network-Tactical Increment 2 (WIN-T Inc 2)	1	0
Warfighter Information Network-Tactical Increment 3 (WIN-T Inc 3)	1	0
Totals	184	69

Source: GAO analysis of data from DOD and eSRS. | GAO-16-329SP

Appendix VII: Comments from the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE
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WASHINGTON, DC 20301-3000

ACQUISITION, TECHNOLOGY AND LOGISTICS

MAR 9 2016

Mr. Michael J. Sullivan
Director, Acquisition and Sourcing Management
U.S. Government Accountability Office
441 G St NW
Washington, DC 20548

Dear Mr. Sullivan,

This is the Department of Defense response to the GAO Draft Report, GAO-16-329SP, "Defense Acquisitions: Assessments of Selected Weapon Programs" dated March 2016 (GAO Code 121276).

The Department is pleased that this year's Draft Report, the 14th annual assessment on the performance of DoD's major acquisition programs, identifies many ways in which the Department continues to drive down the cost of the acquisition portfolio. GAO results appear to validate our focus on continuous improvement on the cost, schedule, and performance measures of our programs through employment of the Better Buying Power initiatives. The enclosed chart illustrates the five-year moving average of the annual growth of contracted costs over the past thirty years, note that it shows a steep decline in contract cost growth following the implementation of Better Buying Power.

The Department appreciates the opportunity to comment on the Draft Report. My point of contact for this effort is LCDR Joseph Mitzen, 703-697-8020.

Sincerely,

Nancy L. Spruill

Nancy L. Spruill
Director
Acquisition Resources & Analysis

Enclosure:
As stated

Appendix VIII: GAO Contact and Staff Acknowledgments

GAO Contact

Michael J. Sullivan, (202) 512-4841 or sullivanm@gao.gov

Staff Acknowledgments

Principal contributors to this report were J. Kristopher Keener, Assistant Director; Enyinnaya David Aja; Desirée E. Cunningham; Matthew T. Drerup; Danny Owens; and Wendy Smythe. Other key contributors included, Cheryl Andrew, Naba Barkakati, Emily Bond, Edwin B. Booth, Jennifer A. Dougherty, Rich Horiuchi, Julia Kennon, Jill N. Lacey, Kate Lenane, Jean L. McSween, Travis J. Masters, LaTonya Miller, Diana L. Moldafsky, Scott M. Purdy, Beth Reed Fritts, Ronald E. Schwenn, Bill Shear, Charlie Shivers, Roxanna T. Sun, Jay Tallon, Lindsay C. Taylor, Bruce H. Thomas, Oziel A. Trevino, and Alyssa Weir. The following were responsible for individual programs:

Current programs	
Program name	**Primary staff**
AIM-9X Block II Air-to-Air Missile	Jennifer A. Dougherty, Stephen V. Marchesani, Cale Jones
Air and Missile Defense Radar (AMDR)	Sean D. Merrill, Laura M. Jezewski, Nathan Foster
Airborne & Maritime/Fixed Station (AMF)	Lindsay C. Taylor, Scott M. Purdy
Amphibious Combat Vehicle (ACV)	Jenny Shinn, Zachary Sivo, Betsy Gregory-Hosler
Armored Multi-Purpose Vehicle (AMPV)	Andrea M. Bivens, Marcus C. Ferguson
B-2 Defensive Management System Modernization (B-2 DMS-M)	Matthew B. Lea, Don M. Springman
CH-53K Heavy Lift Replacement Helicopter	Robert K. Miller, Brian T. Smith
Combat Rescue Helicopter (CRH)	Sean C. Seales, J. Andrew Walker
Common Infrared Countermeasure (CIRCM)	Danny Owens, Wendy Smythe
CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)	Burns C. Eckert, Abby C. Volk, Kelsey Hawley
DDG 51 Flight III Destroyer (DDG 51 Flight III)	Laura M. Jezewski, Sean D. Merrill, Nathan Foster
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	Angie Nichols-Friedman, Patrick Breiding, Garrett Riba
Enhanced Polar System (EPS)	Bradley L. Terry, Maricela Cherveny
Evolved Expendable Launch Vehicle (EELV)	Andrew Redd, Erin E. Cohen, Desirée E. Cunningham
F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)	Julie C. Hadley, Robert P. Bullock
F-35 Joint Strike Fighter Aircraft (F-35 JSF)	Megan Sester, Jillena S. Roberts, Samuel Woo
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)	Alexandra Dew Silva, Jessica E. Karnis, Justin Jaynes
Global Positioning System III (GPS III)	Laura T. Holliday, Raj Chitikila
Ground/Air Task Oriented Radar (G/ATOR)	Joe Hunter, Bonita J. P. Oden
Handheld, Manpack, and Small Form Fit Radios (HMS)	Scott M. Purdy, Jessica E. Karnis
Integrated Air and Missile Defense (IAMD)	Carol T. Mebane, Meredith A. Kimmett
Joint Air-to-Ground Missile (JAGM)	Daniel Singleton, Wendy Smythe
Joint Light Tactical Vehicle (JLTV)	Marcus C. Ferguson, Andrea M. Bivens

Program name	Primary staff
KC-46A Tanker Modernization Program (KC-46A)	Katheryn S. Hubbell, Nathaniel Vaught Jeffrey L. Hartnett
LHA 6 America Class Amphibious Assault Ship (LHA 6)	Abby C. Volk, Teague A. Lyons, Matthew Jacobs
Littoral Combat Ship (LCS)	Jacob Beier, C. James Madar
Littoral Combat Ship - Mission Modules (LCS Packages)	Laurier R. Fish, Jacob Beier
M109A7 Family of Vehicles (M109A7 FOV)	William C. Allbritton, Richard Cederholm
Military Global Positioning System User Equipment Increment 1 (MGUE)	Raj Chitikila, Andrew Redd
MQ-4C Triton Unmanned Aircraft System (MQ-4C)	Don M. Springman, Tom Twambly
MQ-8 Fire Scout Unmanned Aircraft System (MQ-8 Fire Scout)	James Kim, Justin Jaynes, Jeffrey Harner
Next Generation Jammer Increment 1 (NGJ Increment 1)	Teakoe S. Coleman, Laura T. Holliday
Next Generation Operational Control System (OCX)	Claire A. Buck, Erin R. Cohen, Maricela Cherveny
Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1)	Tom Twambly, Laurier R. Fish, Ji Byun
Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE)	Meredith A. Kimmett, Carol T. Mebane
Ship to Shore Connector Amphibious Craft (SSC)	Teague A. Lyons, Beth Reed Fritts, Molly Callaghan
Small Diameter Bomb Increment II (SDB II)	John W. Crawford, Carrie W. Rogers
Space Fence Ground Based Radar System Increment 1 (Space Fence Inc 1)	Laura D. Hook, Suzanne Sterling
Three-Dimensional Expeditionary Long-Range Radar (3DELRR)	Claire Li, Joe Hunter
VH-92A Presidential Helicopter (VH-92A)	Bonita J. P. Oden, Robert K. Miller
Warfighter Information Network-Tactical Increment 2 (WIN-T Inc 2)	Andrea Yohe, Ryan Stott
Warfighter Information Network-Tactical Increment 3 (WIN-T Inc 3)	Ryan Stott, Andrea Yohe
Future Programs	
Advanced Pilot Trainer (APT)	Marvin E. Bonner, Sean C. Seales
Amphibious Ship Replacement (LX(R))	Holly Williams, Jenny Shinn, Zachary Sivo
F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)	Wendell K. Hudson, LeAnna M. Parkey
Improved Turbine Engine Program (ITEP)	Wendy Smythe, Daniel Singleton
Indirect Fire Protection Capability Increment 2 – Intercept, Block 1 (IFPC Inc 2, Block 1)	Helena Johnson, James P. Haynes
Joint Surveillance Target Attack Radar System Recapitalization (JSTARS Recap)	J. Andrew Walker, Sameena Ismailjee, Alexandra Stone
Ohio-class Replacement (Ohio Replacement)	C. James Madar, Christopher J. Yun
P8-A Increment 3 Upgrade Program (P8-A Inc 3)	Heather B. Miller Jocelyn C. Yin
Presidential Aircraft Recapitalization (PAR)	LeAnna M. Parkey, Wendell K. Hudson
Unmanned Carrier Launched Airborne Surveillance and Strike (UCLASS) System	Robert P. Bullock, Julie C. Hadley
Weather Satellite Follow-On (WSF)	Maricela Cherveny, Brenna E. Guarneros

Related GAO Products

Ford Class Aircraft Carrier: Poor Outcomes Are the Predictable Consequences of the Prevalent Acquisition Culture. GAO-16-84T. Washington, D.C.: October 1, 2015.

Missile Defense: Opportunities Exist to Reduce Acquisition Risk and Improve Reporting on System Capabilities. GAO-15-345. Washington, D.C.: May 6, 2015.

Defense Acquisitions: Assessments of Selected Weapon Programs. GAO-15-342SP. Washington, D.C.: March 12, 2015.

High-Risk Series: An Update. GAO-15-290. Washington, D.C.: February 11, 2015.

Federal Subcontracting: Linking Small Business Subcontractors to Prime Contracts Is Not Feasible Using Current Systems. GAO-15-116. Washington, D.C.: December 11, 2014.

National Defense: Department of Defense's Waiver of Competitive Prototyping Requirement for the Navy's Fleet Replenishment Oiler Program. GAO-15-57R. Washington, D.C.: October 8, 2014.

Ford-Class Aircraft Carrier: Congress Should Consider Revising Cost Cap Legislation to Include All Construction Costs. GAO-15-22. Washington, D.C.: November 20, 2014.

Littoral Combat Ship: Navy Complied with Regulations in Accepting Two Lead Ships, but Quality Problems Persisted after Delivery. GAO-14-827. Washington, D.C.: September 25, 2014.

Defense Acquisitions: Review of Private Industry and Department of Defense Open Systems Experiences. GAO-14-617R. Washington, D.C.: June 26, 2014.

Defense Acquisitions: Assessments of Selected Weapon Programs. GAO-14-340SP. Washington, D.C.: March 31, 2014.

F-35 Joint Strike Fighter: Problems Completing Software Testing May Hinder Delivery of Expected Warfighting Capabilities. GAO-14-322. Washington, D.C.: March 24, 2014.

Navy Shipbuilding: Significant Investments in the Littoral Combat Ship Continue Amid Substantial Unknowns about Capabilities, Use, and Cost. GAO-13-530. Washington, D.C.: July 22, 2013.

Defense Acquisitions: Assessments of Selected Weapon Programs. GAO-13-294SP. Washington, D.C.: March 28, 2013.

High-Risk Series: An Update. GAO-15-290. Washington, D.C.: February 2015.

Defense Acquisitions: Assessments of Selected Weapon Programs. GAO-12-400SP. Washington, D.C.: March 29, 2012.

Arleigh Burke Destroyers: Additional Analysis and Oversight Required to Support the Navy's Future Surface Combatant Plans. GAO-12-113. Washington, D.C.: January 24, 2012.

Defense Acquisitions: Assessments of Selected Weapon Programs. GAO-11-233SP. Washington, D.C.: March 29, 2011.

Best Practices: DOD Can Achieve Better Outcomes by Standardizing the Way Manufacturing Risks Are Managed. GAO-10-439. Washington, D.C.: April 22, 2010.

V-22 Osprey Aircraft: Assessments Needed to Address Operational and Cost Concerns to Define Future Investments. GAO-09-692T. Washington, D.C.: June 23, 2009.

Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding. GAO-09-322. Washington, D.C.: May 13, 2009.

GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs. GAO-09-3SP. Washington, D.C.: March 2, 2009.

Defense Acquisitions: A Knowledge-Based Funding Approach Could Improve Major Weapon System Program Outcomes. GAO-08-619. Washington, D.C.: July 2, 2008.

Defense Acquisitions: Realistic Business Cases Needed to Execute Navy Shipbuilding Programs. GAO-07-943T. Washington, D.C. July 24, 2007.

Defense Acquisitions: Stronger Management Practices are Needed to Improve DOD's Software-Intensive Weapon Acquisitions. GAO-04-393. Washington, D.C.: March 1, 2004.

Best Practices: Using a Knowledge-Based Approach to Improve Weapon Acquisition. GAO-04-386SP. Washington, D.C.: January 2004.

Multiyear Procurement Authority for the Virginia Class Submarine Program. GAO-03-895R. Washington, D.C.: June 23, 2003.

Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes. GAO-02-701. Washington, D.C.: July 15, 2002.

Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes. GAO-01-288. Washington, D.C.: March 8, 2001.

Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes. GAO/NSIAD-99-162. Washington, D.C.: July 30, 1999.

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